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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

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DEPARTMENT OF [illegible]

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AN ANALYSIS OF THE WATER RESOURCES OF THE COWICHAN RIVER BASIN, VANCOUVER ISLAND

by

SUSAN MACKENZIE ARNELL

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled An Analysis of the Water Resources of the Cowichan River Basin, Vancouver Island, submitted by Susan Mackenzie Arnell in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

In the Cowichan River basin, problems of water supply, flood control, irrigation, fishing, and recreation are water resource problems which have become apparent in recent years. This thesis is an inventory and description of the water resources of the basin and their utilization. Surface and groundwater supplies, and the water balance for the basin have been investigated. Water use for domestic, industrial, agricultural, mining, power, fish, wildlife, recreation and navigation have been examined for trends in utilization and conflicts between uses. Recreational use of the water resource in fishing and park development was found to conflict with domestic, industrial and agricultural use on several counts. The thesis concludes with recommendations for additional research and specific planning.

ACKNOWLEDGEMENTS

The author is indebted to the British Columbia Water Investigations Branch for the opportunity of undertaking this study of the Cowichan River basin. The use of the Branch facilities was a great aid in the preparation of the material. Mr. V. Raudsepp, Chief Engineer, merits special thanks for his interest and support during the early stages of the research.

I wish to thank the staff of the British Columbia Water Investigations Branch, the Department of Agriculture, the Fish and Game Branch, and the Parks Branch; the public officials of Duncan, the District Municipality of North Cowichan, and the Village of Lake Cowichan; and the company personnel at Honeymoon Bay, Mesachie Lake, Youbou, and Caycuse for their willing and generous assistance.

My thesis supervisor, Dr. E.E. Hanlon deserves particular thanks for her encouragement and constructive criticism during the preparation of this thesis. Thanks are also due to Professor A.H. Laycock for his assistance in criticizing portions of the manuscript.

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INTRODUCTION

Man has long harnessed water for his use through diversion for urban consumption and the development of irrigation schemes. Until recently in the development of his knowledge, the nature of the water cycle or the effect of the intervention of man upon it, were little understood. Indeed, it is only in the twentieth century that man has solved some of the problems of the mechanics of flow, the rhythm of the water cycle, and modification of the water resource. It is also in this century that increased utilization of the water resource in industry and agriculture by a rapidly growing population has added urgency to the need for solutions to unknowns in hydrology and water management.

The United States, particularly since the Second World War, has had a constantly growing programme of watershed management and river basin development. Interest in the management of the water resource originally grew out of critical problems of water shortage, pollution, flooding, erosion, and sedimentation. These problems continue to be an impetus to new studies, especially because of the success achieved through earlier programmes of river basin planning.

Increasingly, however, the importance of water resource development in ensuring and promoting economic growth of a region is providing the justification for research. Water resource studies are becoming preventative rather than curative in their approach.

In Canada, water resource programmes have been slow in development because of an abundance of water and low population densities. The Conservation Authorities of Ontario, set up originally for control of flooding and soil erosion, and now exapanded to include development of a river basin for other purposes, such as recreation, is almost alone as a vehicle for watershed development in the country. Under the Prairie Farm Rehabilitation Administration some studies have been undertaken in western Canada on flooding and irrigation but their work has been limited and more specifically oriented toward agriculture. Isolated watershed studies and specific river basin development schemes have been undertaken from time to time, but a real interest in the planned development of the water resource is just beginning. The Water Resources Branch of the newly organized Federal Department of Energy, Mines and Resources has been given a broad mandate for water resources research and management in Canada. Under The Agricultural and Rural Development Act studies on water resources are also being

undertaken in connection with their programme. Provincial governments too are beginning to look beyond specific problems to more general inventory and planning. This study, sponsored by the British Columbia Water Investigations Branch in the summer of 1966, is part of this new interest in water resources development in Canada.

The Cowichan River basin on Vancouver Island in British Columbia has a history of local requests leading to small-scale studies, and limited government action on problems of water supply, flood control, irrigation, recreation and fishing. Regional pressure exists for improvement in domestic water servicing, particularly in the lower basin where the rural non-farm population is in greatest concentration. Committees, government-initiated studies, and limited implementation of control measures have been applied to the problem of flooding. Local committees have asked for government aid in meeting irrigation requirements and some investigation of this has been undertaken. Residents of the basin have recognized the area as an excellent recreation and fishing centre and have made requests for the reservation of park land and the development of the sports fishery. The region is one of growing population and increased pressure upon the water and related land resources. These issues, incompletely

resolved in the past, linger on, growing in significance as the area develops.

The Water Investigations Branch of the British Columbia Department of Lands, Forests and Water Resources is a research body for studying problems of water resource management. Since the creation of the Branch in 1962, its activities have had to concentrate on specific and immediate problems of flooding, drainage and erosion; of water supply for domestic and irrigation purposes; and of collection of basic meteorological, hydrological and groundwater data. Planning has therefore been restricted to a few water conservation studies in areas where readily available water supplies have been exhausted. The need for a more comprehensive approach to water resource development is recognized by government officials. Piecemeal studies of isolated problems can be no replacement for multiple purpose studies which investigate the interrelationships of the many facets of water management and water use. Through comprehensive regional or watershed investigations, individual problems can be isolated and placed in perspective for timely solution. As more staff become available and the pressure of small scale studies eases, more broadly based studies are likely to be undertaken.

The author was employed by the Water Investigations

Branch in the summer of 1966 to undertake a multiple purpose geographical study of the water resources of the Cowichan River basin. The resulting study is a problem analysis of water and related land resources in the watershed. It is an attempt to describe the land and water resources as they now exist, to determine the present use of these resources, and to analyse and suggest solutions to present as well as possible future problems. A comprehensive rather than a single purpose approach has been taken, because only through an understanding of the interrelationships of the many features of the drainage basin can wise and economic development be undertaken.

The study begins with an inventory of the land and water resources of the Cowichan basin. Much of the information on geology, terrain, soils and vegetation comes from material collected by the British Columbia Government. Streamflow readings and meteorological records have been compiled by the Federal Government. The inventory is followed by a discussion of the utilization of the water resource. Water use for domestic, industrial, agricultural, mining, power, fish, wildlife, recreation and navigation were examined for trends in utilization and conflicts between uses. Water licences, detailing allowable withdrawal from surface water bodies, and a well inventory indicating groundwater use, were made available by the

British Columbia Department of Lands, Forests and Water Resources. Interviews with local officials, and a questionnaire survey undertaken among the agricultural and rural non-farm populations along the coastal plain were further sources of information. The study concludes with recommendations for further research and the commencement of regional planning.

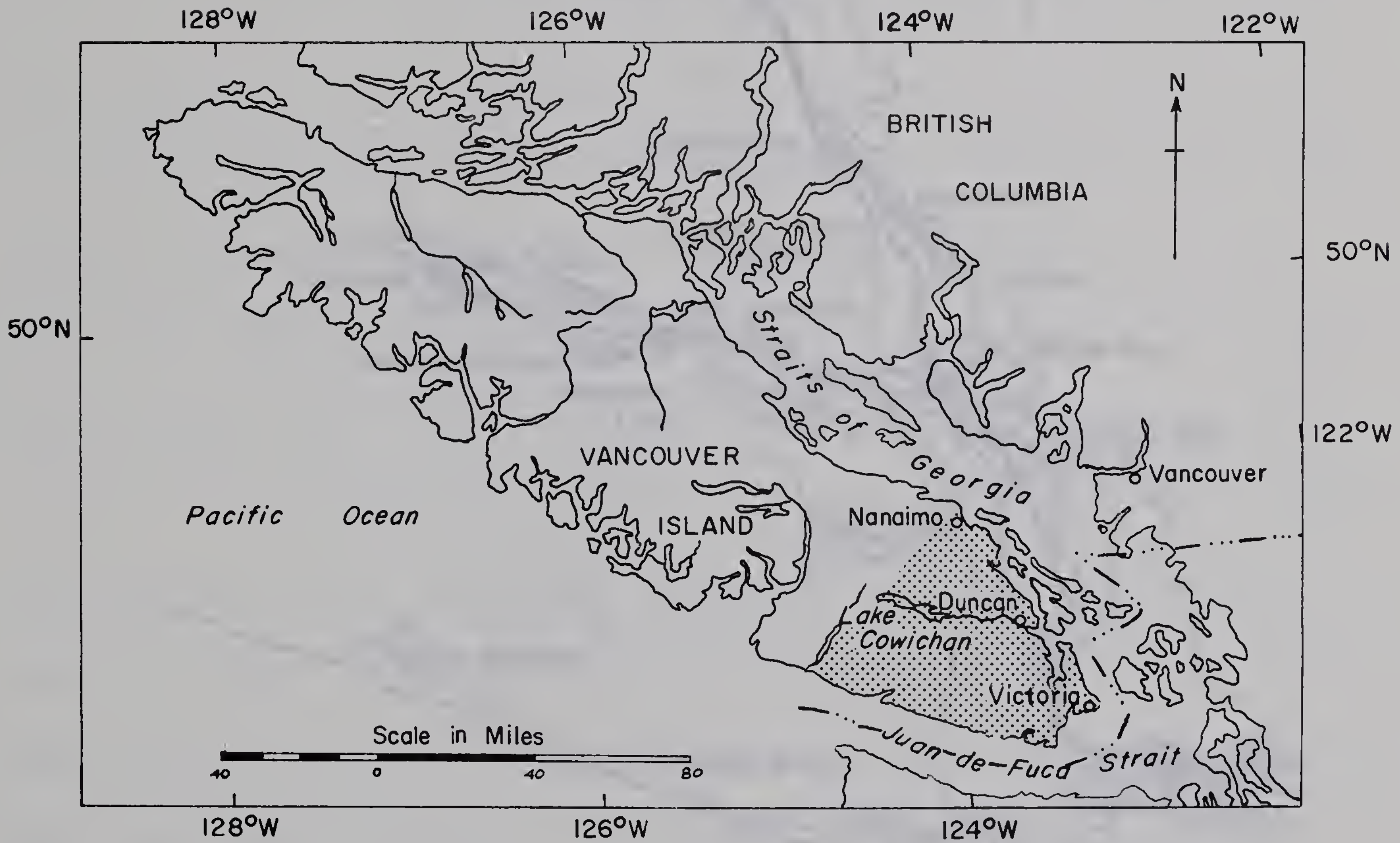
CHAPTER I

DESCRIPTION OF THE COWICHAN BASIN

The Cowichan River basin is situated thirty miles northwest of Victoria on the southern portion of the east coast of Vancouver Island (Fig. 1). The basin is an elongated wedge pressing westward into the centre of the island. Its waters are carried from the interior uplands, along the main valley, and across the coastal plain to the Straits of Georgia, the waterway dividing Vancouver Island from the mainland. The Cowichan River is the fourth largest by volume of flow of the rivers on the island.

The Cowichan basin is linked to the communities along the east coast of Vancouver Island but it is cut off from the undeveloped west coast by mountains (Fig. 2). The eastern portion of the basin is traversed by the Island Highway which runs the full length of Vancouver Island. A secondary paved road connects the Island Highway to the lower end of Lake Cowichan. An unpaved road follows the southern shore of the lake to its head. Logging roads, open for public travel on weekends only, surround the lake and provide a link with the

SOUTHWEST BRITISH COLUMBIA
INCLUDING
VANCOUVER ISLAND



Source: British Columbia
Dept. of Lands, Forests
and Water Resources,
Vancouver Island Bulletin

Fig. 1

COWICHAN RIVER BASIN
LOCATION MAP

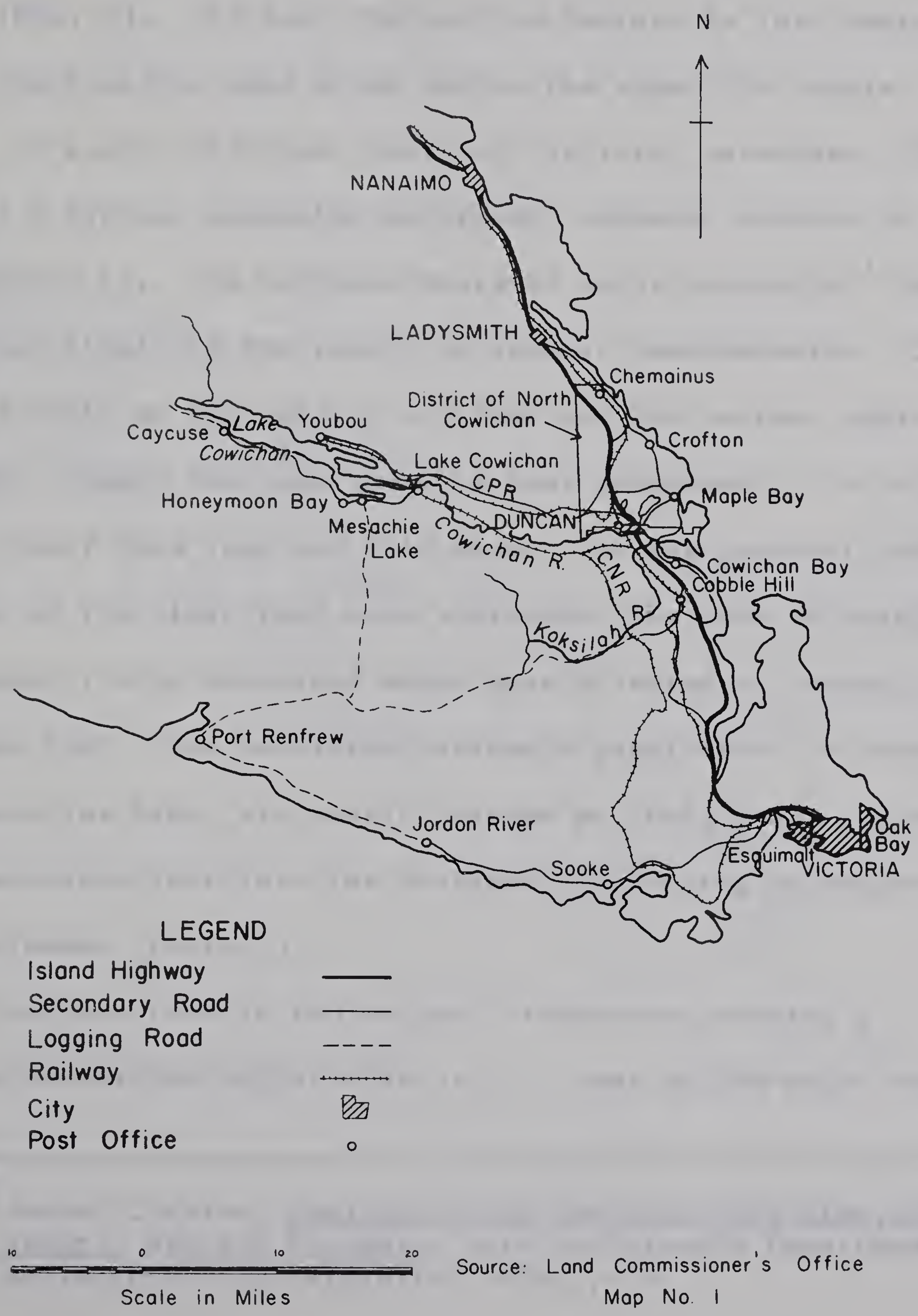


Fig. 2

small communities on the southern coast of Vancouver Island. Railway lines parallel the road network as far as the lower lake.

The Cowichan watershed has a total area of 480 square miles (Fig. 3). Its most distinctive feature is the twenty mile long Cowichan Lake which drains the upper 235 square miles, or almost fifty per cent, of the total watershed. The lake is a narrow, elongated waterbody, somewhat sinuous in form (Photo 1). Its northern shore is fault controlled[1] but the basin itself is the result of glacial overdeepening. The average depth of the lake is 167 feet and the maximum depth 492 feet. Where the lake shore is best developed it is but a narrow shelf less than one mile wide. For the greatest proportion of its sixty-four mile shoreline, the lake is bounded by steeply rising mountains which have a relief of several thousand feet. The mountains, although precipitous in their rise from the lake, are gently rounded at their peaks and fall back rank upon rank into the distance, increasing in height to the northwest (Photo 2).

Cowichan Lake is fed by many tributaries forming a trellis network on either side of it. Some of the major ones

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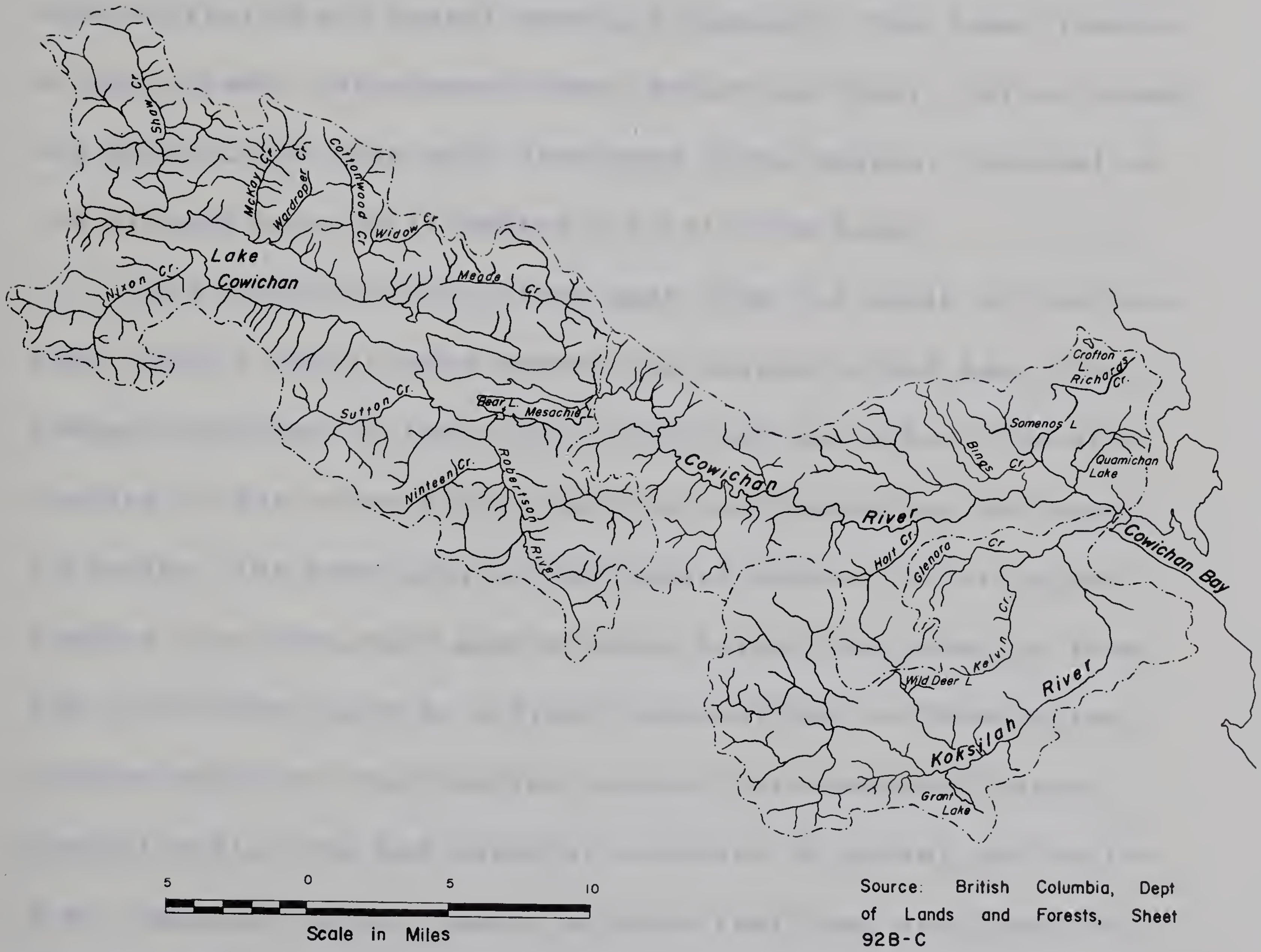
[1] James T. Fyles, Geology of the Cowichan Lake Area, Vancouver Island, British Columbia, British Columbia Department of Mines, Bulletin No. 37, Victoria, 1955, p. 9.

COWICHAN RIVER BASIN

DRAINAGE



Source: British Columbia, Dept of Lands and Forests, Sheet 92B-C

Fig. 3

are Shaw Creek, McKay Creek, Cottonwood Creek, Meade Creek, Robertson River, Sutton Creek, and Nixon Creek. The streams occupy steep, narrow valleys with gradients up to 2000 feet per mile on the shorter, more precipitous ones, and several hundred feet per mile on the longer, more moderately sloping ones. Many of the smaller streams are intermittent. During the summer months even the larger ones have greatly reduced flow so that their gravel beds are exposed. The lower reaches of Shaw Creek, Cottonwood Creek, Robertson River, Sutton Creek, and Nixon Creek have well developed flood plains. Several of the streams have built deltas out into the lake.

The Cowichan River flows east from the mouth of Cowichan Lake along a thirty mile meandering course to the sea. The average gradient of the river is 20 feet per mile. The area drained by the river below the lake, and excluding its major tributary, the Koksilah, is 125 square miles. In its upper reaches from Cowichan Lake to Skutz Falls, the river is from 100 to 200 feet wide in a flood plain of two to three miles. The low banks of this section are cut into unconsolidated glacial till. The bed material consists of gravel and boulders. Numerous pools, twenty or more feet deep, are found in this section. A log jam which has existed for many years and which appears to be firmly established against disruption by

flood flows, blocks the river a mile above Skutz Falls. The jam is 625 feet wide and has created a thirty-five acre swamp upstream from it. A smaller jam 1.5 miles upstream from the falls has now been bypassed by the river (Photo 3). The vegetation on the banks is thick secondary growth which extends to the water's edge (Photo 4). Road access to this section of the river is limited to the vicinity of the Village of Lake Cowichan and Skutz Falls. Foot trails have been established along the nine mile interval between roads. With the exception of the upper few miles of the river this section is largely undeveloped, so that the small amount of flooding or erosion which may occur, has little serious effect.

At Skutz Falls and for 3.5 miles downstream to the lower end of Marie Canyon, with the exception of one low-banked meander loop through gravel just below the falls, the river is incised into shale bedrock (Photo 5). The banks are high and steep; in the mile long Marie Canyon 100 to 150 feet. At Skutz Falls there is a drop of eighteen feet in 300 feet. Elsewhere in this section the gradient is about thirty feet per mile. The only access by road is at Skutz Falls but there are trails along both sides of the river used by fishermen. Flooding and erosion problems are insignificant for the most part in this steeply rock-walled section of the river.

Downstream from Marie Canyon and for 7.5 miles to the mouth of Holt Creek the river resembles the section above Skutz Falls in that it flows over a gravel bed between low sand and gravel banks (Photo 6). For a mile long stretch near the middle of this section there are fine, easily eroded materials into which the river has incised two deep meanders. Vegetation in this section is moderately thick secondary growth and shrubs, extending to the water's edge. Access is by road along the north bank of the river and by foot path along the south bank. Some development of private properties has been undertaken. Flooding is local in extent and appears to have been dealt with adequately by individual property owners.[2] Erosion is more serious. Bank erosion and abandonment of meanders is evident throughout this section. Logging debris often accelerates changes in channel location by restricting normal channels during peak flows.

In the five mile section between Holt Creek and Duncan the river flows between steep rocky banks, fifty to one hundred feet high. Flooding and erosion are not significant for most of this stretch. At the point west of Duncan, where the

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[2]British Columbia Department of Lands and Forests, Water Rights Branch, Preliminary Report Respecting Flooding and Erosion on the Cowichan River, Vol. 1, Victoria, 1959, p. 11.

power line crosses the river, however, erosion is proceeding fairly actively into a bank of unconsolidated gravels (Photo 7).

Between Cowichan Lake and Duncan the river valley is bordered by rounded mountains several thousand feet high. From Duncan the river flows for about 4.5 miles over the more open coastal plain to join the sea at Cowichan Bay (Photo 8). In this section the flow is augmented by drainage from the Somenos and Quamichan basins, and by the Koksilah River. The river is about 200 feet wide in a flood plain of several miles. Here the river gradient is least, ten feet per mile, and deposition as a result of loss of velocity accentuates the meander pattern. Bed material is gravel, grading downstream into gravel with a silt veneer. The river valley has been most intensively developed along these lower reaches. Duncan on the north bank of the main stem, is the largest settlement in the basin. Downstream the river is flanked by Indian reservations which although not intensively utilized, represent the source of livelihood for a significant segment of the population. Flooding and erosion are at their most serious along this part of the river (Photo 9). Some attempt to contain flood flows within the river channel by dredging of the river bottom and the building of gravel banks

has been undertaken by local authorities. Little has been done to prevent erosion of the banks in the lower course of the river.

The Koksilah is the largest tributary of the Cowichan River. Except for the last quarter mile of its course it could be an independent stream flowing directly to the sea. In fact, old stream channels indicate that in the past it was a separate river. The Koksilah rises in a poorly drained upland region south of the middle section of the Cowichan River. It flows southeast and then northeast along a twenty mile course to join the Cowichan River at its mouth. The river drains an area of 120 square miles. It is fed by many small tributaries, some of which are intermittent in their flow. The river occupies a narrow, moderately steep valley except for the last few miles when it flows across the coastal plain. In the mountainous section the average river gradient is fifty-five feet per mile. On the coastal plain it drops to sixteen feet per mile. Grant Lake provides the only significant storage in this basin. The lake is on a short tributary to the Koksilah and so it does little to modify the irregular, flashy flow of the main stem.

Physiography

The Cowichan River basin lies within the western system

of the Canadian Cordillera.[3] It includes within its boundaries two physiographic subdivisions; the coastal lowland, a narrow belt of lowlying land on the eastern coast of Vancouver Island, and the insular mountains, the higher area inland from the coast (Fig. 4).[4] The configuration of the land is the result of uplift and dissection followed by glacial erosion and deposition. Faulting has been an important physiographic control throughout the geologic history of the area. Rejuvenation of streams by post-glacial uplift has led to renewed downcutting.

The insular mountains comprise the uplands of the Cowichan valley. Because the centre of uplift on Vancouver Island

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[3] Stuart S. Holland, Landforms of British Columbia: A Physiographic Outline, British Columbia Department of Mines and Petroleum Resources, Bulletin No. 48, Victoria, 1964, p. 4.

[4] Stuart Holland in his Landforms of British Columbia: A Physiographic Outline delineates two physiographic subdivisions for the Cowichan drainage basin, the Nanaimo Lowland and the Insular Mountains. He uses the 2000 foot contour to delimit the boundary between the two. On a large scale map the 2000 foot contour occurs well up the break in slope between the mountains and the plain. It also includes within the lowland all of the Cowichan River valley and Cowichan Lake, a major portion of which is part of a mountainous rather than a coastal terrain. For this paper the 1000 foot contour has been chosen as the boundary between the coastal lowlands and the insular mountains on the east facing slopes of the basin. The extension of the boundary into the river valley has been carried just beyond Skutz Falls, a break in the river profile indicating the upper limit of downcutting since post-glacial rejuvenation.

COWICHAN RIVER BASIN

PHYSIOGRAPHIC REGIONS

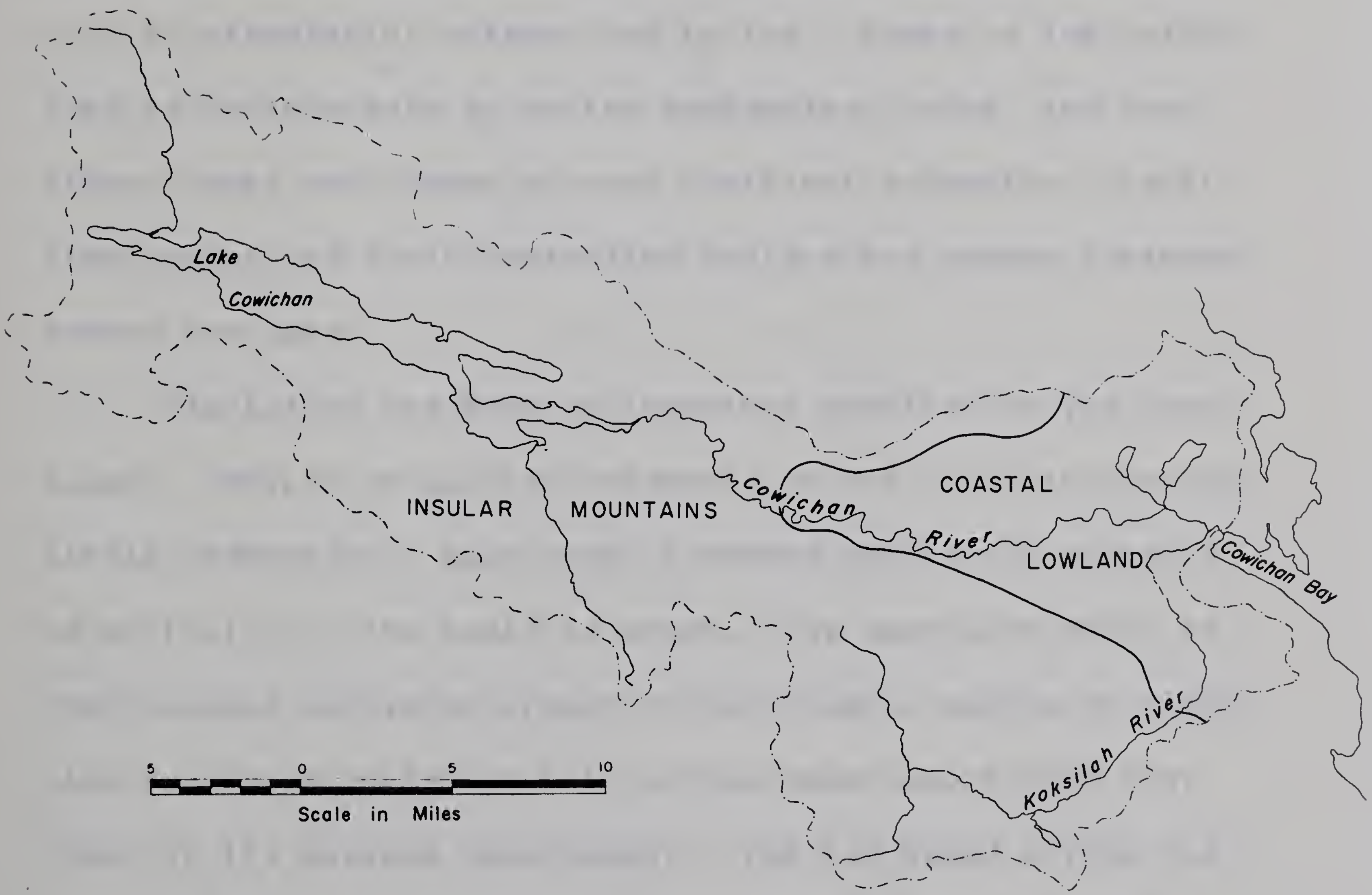

Fig. 4

was northwest of the Cowichan basin, elevations decrease from the northwest to the southeast. The highest peaks in the basin, just over 5000 feet, are found north of the lake. To the southeast the relief decreases quite rapidly. The mountains are composed of volcanic and sedimentary rocks which have been folded about a northwesterly trending axis and intruded by numerous batholiths.[5] The mountains are the result of mature dissection of a low relief erosion surface both by pre-glacial streams and by ice. Areas of low relief tend to be underlain by softer sedimentary rocks, and the higher peaks and ridges by more resistant volcanics. Fault-line scarps and fault-controlled valleys are common features around the lake.

Glaciation has been an important modifier of the landscape. Details of glacial movements in the Cowichan area are little understood. Much work is needed before the sequence of activity for the basin is known. The mountains north of the Cowichan watershed appear to have been a source of alpine glaciers which coalesced into an ice sheet about 5000 feet thick at its maximum development. The ice moved across the Cowichan basin in a southerly to southeasterly direction

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[5] Holland, op. cit., p. 31.

moulding a stoss and lee topography. At its maximum extension this ice sheet merged with the Cordilleran sheet in the Straits of Georgia and some reversal of flow may have taken place. During deglaciation the mountains emerged again but the valleys retained ice tongues. One such tongue occupied the Cowichan valley and moved eastward beyond Cowichan Bay leaving ice contact deltas, and kettles and kame deposits as it stagnated.[6]

The coastal lowland is part of a depression between the Coast Mountains of mainland British Columbia and the insular mountains of Vancouver Island. The lowland is underlain by sedimentary rocks which rest unconformably upon older volcanic and metamorphic rocks.[7] Surficial deposits of glacial origin with thicknesses from several feet to almost 200 feet cover most of the land below the 500 foot contour.[8] At higher elevations the bedrock may be exposed or covered by a thin mantle of glacial or residual materials. The lowland is made up of an alternation of low ridges and narrow valleys which follow the northwest strike of the rock. The form is the

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[6]E.C. Halstead, Surficial Geology of Duncan and Shawnigan Map - Areas, British Columbia. Geological Survey of Canada, Paper 65-24, 1966, p. 1.

[7]C.H. Clapp, Sooke and Duncan Map - Areas, Vancouver Island, Canada, Department of Mines, Geological Survey, Memoir 96, Ottawa, 1917, p. 14

[8]Halstead, op. cit., p. 1.

result of differential erosion of the more resistant sandstone and conglomerates, and the less resistant shales. Faulting appears to have accentuated the trend of some of the valleys.[9] Post glacial uplift has led to rejuvenation of the streams. In the middle reaches of the Cowichan River this has resulted in the formation of Marie Canyon as described above.

Settlement

The original people of the Cowichan River basin were Indians[10] who lived in small bands, gaining a livelihood by fishing, hunting and gathering. Europeans came to the area as adventurers and settlers during the nineteenth century. The first organized party of settlers arrived in 1862 when one hundred men were sponsored under a government scheme of colonization. Prior to their arrival only a handful of settlers had taken up residence in the basin as it was the policy of the governing Hudson Bay Company to discourage settlement despite provisions of their mandate from the British Government to foster it.[11]

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[9] Holland, op. cit., p. 39.

[10] The Cowichan Indians are part of the Coast Salish linguistic group. There are presently just over a thousand of them in the basin living mainly on the large Indian Reserve near Duncan.

[11] E. Blanche Norcross, The Warm Land, 1959, p. 11.

Initial settlement in the Cowichan basin was near the landing point at Cowichan Bay and inland around Somenos Lake. Cowichan Bay and Maple Bay developed as the first major centres because of the monthly and later weekly calls by the steamer from Victoria. By 1873 the concentration of people north of the Cowichan River was sufficient for the incorporation of the District Municipality of North Cowichan, one of the oldest in British Columbia. Growth was slow in this early period because of the difficulties of transportation to and within the area. A foot path from Victoria to Nanaimo was widened into a wagon trail in 1884. In 1886 the railway was officially opened. The arrival of the railway opened the valley to settlement, made the Victoria market more accessible, and shifted the focus of the area from the steamer docks on the coast to the station inland at Duncan. Settlement moved toward the lake with the beginning of a road from Duncan to Lake Cowichan. By the turn of the century Duncan had developed into the most important community in the valley. In 1912 it had a population of 1500 and was incorporated as a town. Maple Bay changed from a trading community to a resort centre. Cowichan Lake also developed into a popular summer resort.

In the early days of settlement, farming and logging

were the primary means of support for most of the population. Farming was concentrated along the coastal plain where the soils were fertile, the terrain level, and the access easy. Some farming was attempted in the lake region but all save one farm has reverted to forest. Logging was a natural companion to settlement as the land in its original state was heavily forested with merchantable timber. Logging began on the coastal plain and gradually migrated up the river valley to the lake. Copper mining just north of the Cowichan basin assumed importance at the turn of the century and the town of Crofton boomed as the processing and shipping point for the ore.

The valley experienced a period of decline during the First World War followed by a brief resurgence until the depression of the 1930s. Since then there has been a growing prosperity throughout the basin and a steady rise in population (Fig. 5). Following the Second World War more efficient techniques of logging using trucks on the steeper slopes rather than the more restricted railway, and new mills for processing forest products at Honeymoon Bay, Mesachie Lake, and most recently at Crofton, have provided employment opportunities and capital for the area. Duncan has developed as the primary service centre for the valley, and the Village of

COWICHAN RIVER BASIN

POPULATION MAP

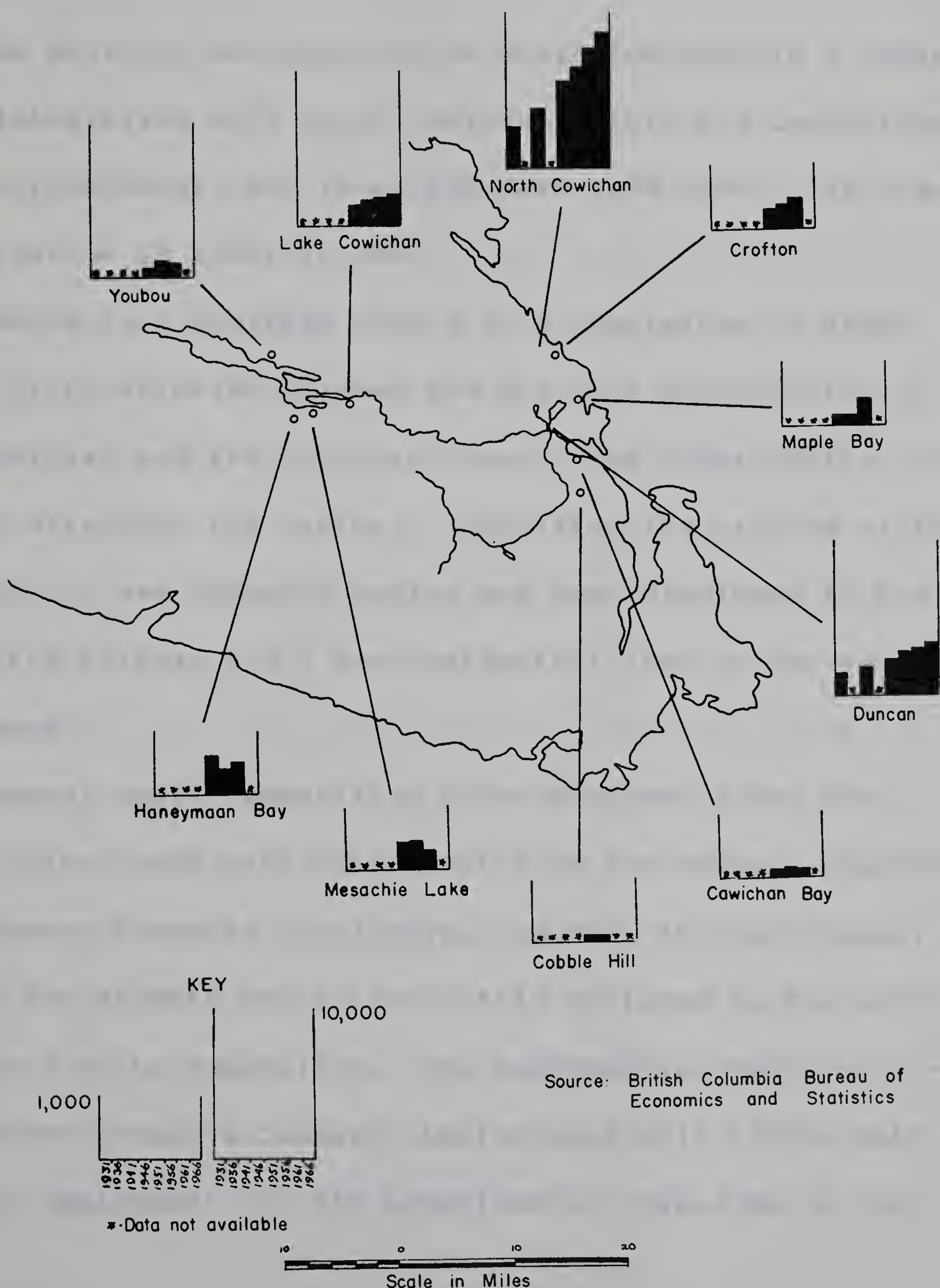


Fig 5

Lake Cowichan, incorporated in 1944, as a secondary one.

The settlements of the Cowichan basin, varied as they are in size and character, are worthy in themselves of a separate study. Here only brief mention may be made of each of them.

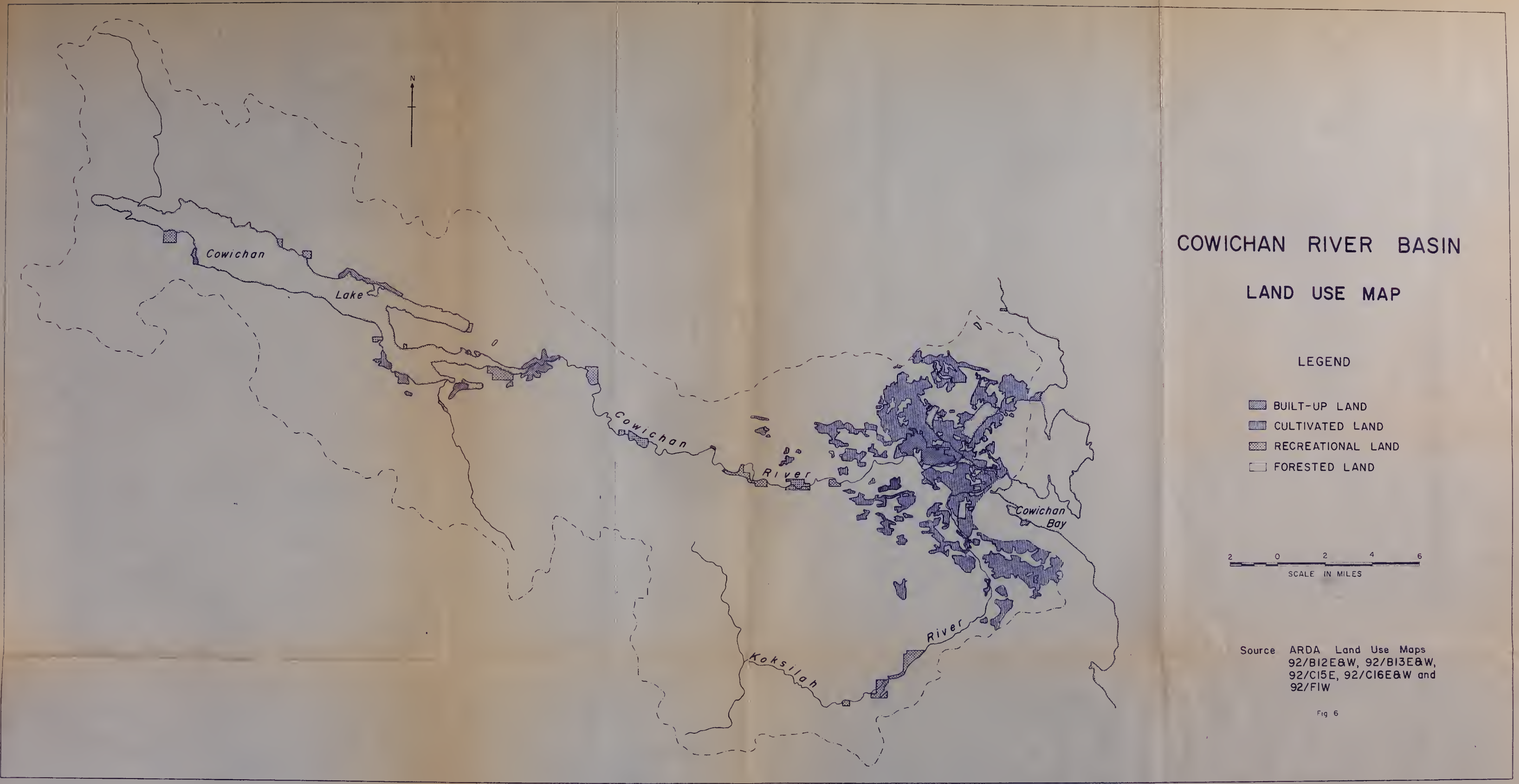
The District Municipality of North Cowichan is a sprawling administrative unit which includes within its boundaries urban, agricultural, and rural non-farm land uses. Its present population is about 10,000.

Duncan is a bustling city with a population of about 4,000. It is situated between the District Municipality of North Cowichan and the Cowichan River. The older section of the town straddles the railway, indicating the origins of the community. A new shopping centre has been developed to the east of the railway and a new residential area on the terrace to the west.

Several small communities have developed along the coastal plain, each quite different from the other. Crofton is an exposed townsite overlooking the sea, the rectangular lines of its streets and houses little softened by the curve of the land or by vegetation. The neighbouring British Columbia Forest Products Company Limited pulp mill is the main source of employment for its inhabitants. Maple Bay a few

miles down the coast, is a picturesque seaside town with the flavour of genteel, old-world living. It is a residential area for employees from Duncan and Crofton, and for retired people. Farther south, Cowichan Bay is a sports fisherman's resort, and a gasoline storage and shipment point. The nucleus of the tiny settlement is a line of houses clinging to the narrow beach. Above the sea terrace a new community is developing nourished by water from deep wells. Inland is Cobble Hill, a cross-roads hamlet where a few loggers and employees from Duncan have made their homes. The lowland surrounding these communities is the centre of agriculture in the basin. The houses are moderately close together as the farms are small.

In the lake region logging is the main source of employment. The Village of Lake Cowichan, a small town of 2,000, situated on level land at the confluence of Lake Cowichan and the Cowichan River, is the major centre on the lake. Just west of the Village of Lake Cowichan on the north shore of the lake, Youbou, a sawmill community of over a thousand people is strung out along the main road. Part of Youbou is a company town and part is privately owned. On the south side of the lake are three company towns; the sawmill communities of Mesachie Lake and Honeymoon Bay, and the


COWICHAN RIVER BASIN
LAND USE MAP
LEGEND
BUILT-UP LAND
CULTIVATED LAND
RECREATIONAL LAND
FORESTED LAND
2 0 2 4 6
SCALE IN MILES
Source ARDA Land Use Maps
92/B12E&W, 92/B13E&W,
92/C15E, 92/C16E&W and
92/F1W
Fig 6
N
Cowichan
Lake
Cowichan
River
Cowichan
Bay
Koksilah
River

permanent logging camp at Caycuse. In each the accoutrements of the forest products industry are the most obvious features but in each the houses and barracks are in pleasant surroundings.

Between the lowland and the lake is a transition zone. There are no nucleated communities. There is very little agriculture in this part of the basin as most of the residents are involved in the forest products industry.

Figure 6 is a generalized land use map based upon the more detailed one recently compiled by the British Columbia Department of Agriculture for the Agriculture and Rural Development Act (ARDA) Land Use Mapping Project. It is a map of the distribution of forest, pasture, cropland and built up areas within the basin.

CHAPTER II

CLIMATE, SOILS AND FORESTS

As background to an analysis of the water resources of an area an understanding of the climate, soils and forests and their effect upon water availability is an important requirement. A study of climate involves weather factors, and the distribution of temperature and precipitation. From these may be drawn information on moisture availability for stream flow and other uses. Soils are an important determinant of drainage and of land use. Forests also affect water movements by increasing soil permeability and by evapotranspiration. A study of these elements, therefore, is a useful addition to the knowledge of the physical environment.

Climate

The Cowichan River basin is in an area of west coast marine climate characterized by mild humid winters, cool dry summers, and a moderate annual temperature range. The dominant air mass affecting the climate is Maritime Polar air from the North Pacific. Incursions of modified Maritime Tropical

and, upon occasion, Polar Continental air may also influence the weather.[1] The proximity of the sea and the presence of the warm North Pacific drift off the British Columbia coast exert a moderating influence.

Temperature and precipitation data are available for varying periods of continuous observation at several points within the basin (Fig. 7). Cowichan Bay has the longest period of continuous published record extending from 1937 to 1964. Duncan follows with records from 1937 to 1957. The Cowichan Lake Forestry station has records from 1950 to 1964. Other stations have records for shorter periods of time: Quamichan from 1888 to 1896, Cobble Hill from 1913 to 1918 and 1924 to 1931, Cowichan Tzouhalem from 1904 to 1925, Cowichan Lake Hatchery from 1938 to 1948, Duncan Forestry from 1958 to 1964, Youbou from 1958 to 1964, and Cowichan Lake Weir from 1960 to 1964.

The shorter records are useful for determining annual changes in climate but for long term trends the more extensive records of Cowichan Bay, Duncan and Cowichan Lake Forestry are more important. These three stations are well located to indicate the distribution of climatic parameters at lower

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[1] Howard J. Critchfield, Climatology, Englewood Cliffs, N.J., 1960, p. 203.

COWICHAN RIVER BASIN
MAP OF RECORDING STATIONS

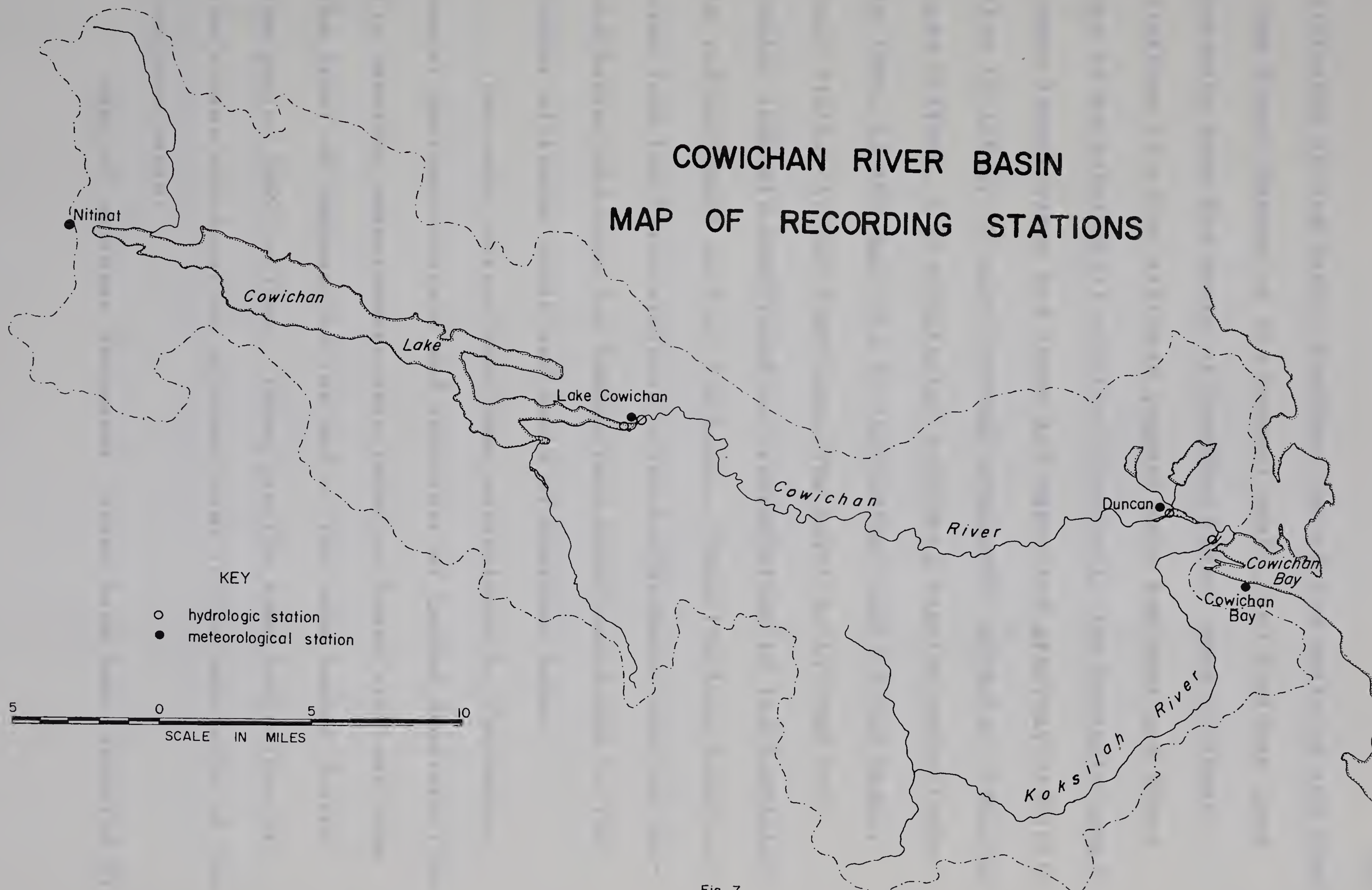

Fig 7

altitudes in the basin; Cowichan Bay at the mouth of the Cowichan River, Duncan on the coastal plain, and Cowichan Lake Forestry near the mouth of Cowichan Lake. None of these stations is at an altitude greater than 600 feet and there are no meteorological stations located in the mountain areas where temperatures are lower and where the greatest precipitation is likely to occur through orographic effects. Cowichan Lake Nitinat, a precipitation recording station established in 1960, is the only one in the western part of the basin. This station is 620 feet above sea level so it does not really indicate conditions of precipitation in the mountains in the northwest part of the basin. Thus the long term averages from the three stations cited are probably low for precipitation and high for temperature when transfered to the higher altitudes north and south of Cowichan Lake.

Two snow courses have been established in the basin, one at Heather Mountain and the other at Lyford Mountain (Fig. 7). Monthly measurements were taken at these stations from the first of February to the end of the snow season during the period 1959 to 1964. These provide some indication of the volume and duration of snow cover in the mountains of the Cowichan basin.

Maps of southern Vancouver Island have been prepared by

the Meteorological Branch of the Department of Transport showing isopleths of climatic parameters.[2] The maps were constructed taking into consideration the uneven distribution of stations and the irregular topography. These, along with data from individual stations have been used to describe the climatic characteristics of the Cowichan River basin.

The mean annual temperature in the Cowichan basin is from 46°F to 51°F. The highest mean annual temperature of 51°F is found at Duncan. Duncan is in a small basin sheltered by hills from direct sea breezes. It tends to have higher temperatures than other stations in the basin because of a mild chinook effect as the westerlies descend after passing over the mountains.[3] At Cowichan Bay where the sea influence is more pronounced, the mean annual temperature is 49°F. Inland at Cowichan Lake Forestry the mean annual temperature is 48°F. The increased elevation of the station probably accounts for the slightly lower temperature average. Temperatures decrease outward from an enclosed area of high averages near Duncan (Fig. 8).

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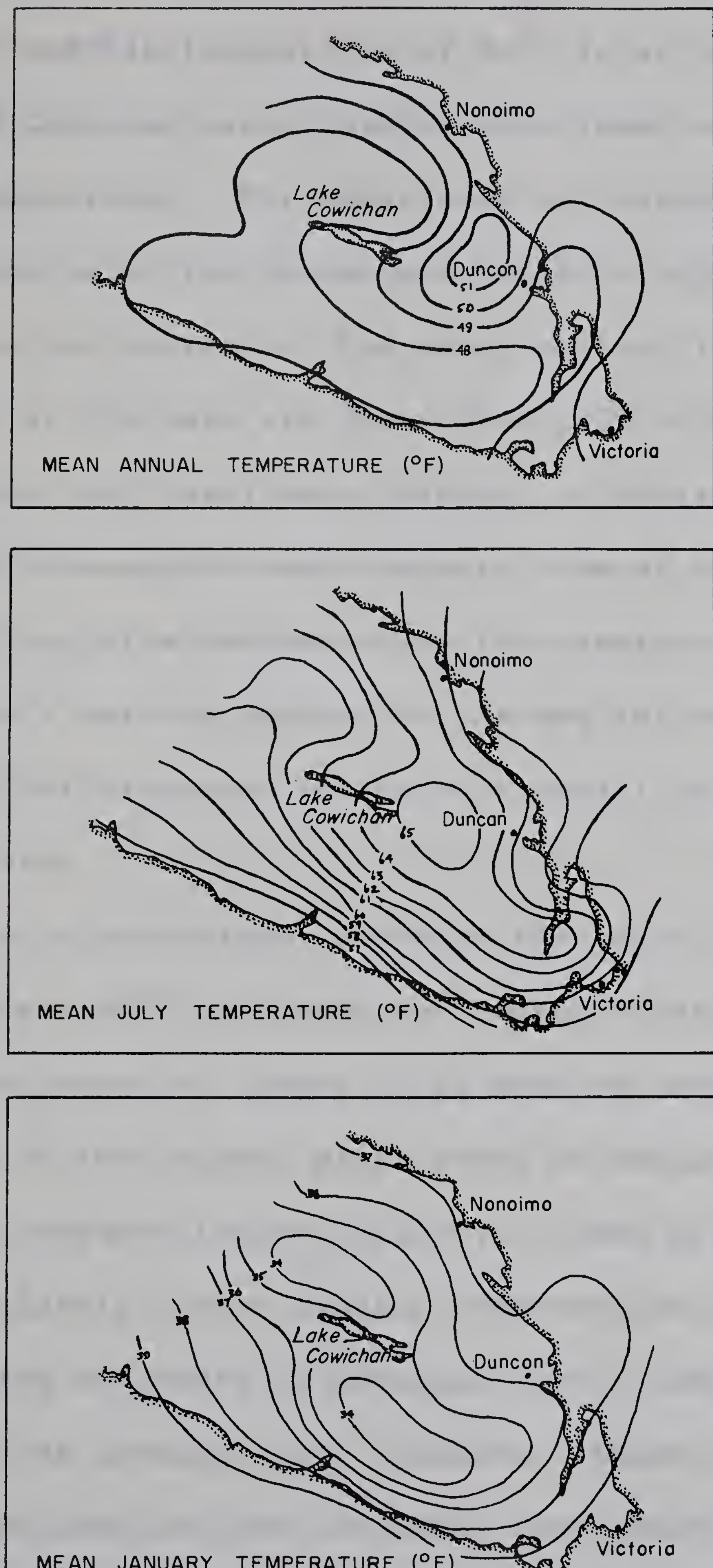
[2] K.F. Harry, Some Aspects of the Climatology of the South-Western B.C. Coast. Department of Transport, Meteorological Division, Cir-2661, Tec - 217, June 2, 1955, 11pp.

[3] *Ibid.*, p. 2.

TEMPERATURE PATTERNS



Source: Dept. of Transport
Meteorologicol Division,
Cir-2661 Tec-217

Fig. 8

July is the warmest month in the Cowichan basin. The highest mean monthly temperature of 65°F is at Duncan. Cowichan Bay and Cowichan Lake Forestry have lower values of 64°F and 63°F respectively. The Department of Transport map (Fig. 8) has a lower value for Duncan and slightly higher values for the other two stations. The basic pattern is probably accurate but as the data are drawn from 1952 climatic summaries the values could well have changed. A centre of high July temperatures exists over the main stem of the Cowichan River. The isopleths decrease from this centre in all directions to form a pattern similar to the one for mean annual temperatures but displaced inland as a result of greater heating of the land.

January is the coldest month in the basin. Mean monthly temperatures are 36°F at Duncan and Cowichan Bay, and 34°F at Cowichan Lake Forestry. There is an area of warmer January temperatures on the coastal plain north of Duncan from which temperatures decrease inland (Fig. 8). There are two large islands of slightly cooler January temperatures over the mountains north and south of Cowichan Lake. January temperatures are on the average above freezing. There is the odd winter such as 1950 and 1957 in which mean temperatures for January are driven below 32°F by outbreaks of Polar

Continental air from interior British Columbia. Daily temperatures of $0^{O}F$ are rare.

The annual temperature range in the Cowichan basin is much smaller than for continental locations in similar latitudes. The moderating influence of the sea keeps the annual range to between $25F^{O}$ and $30F^{O}$.

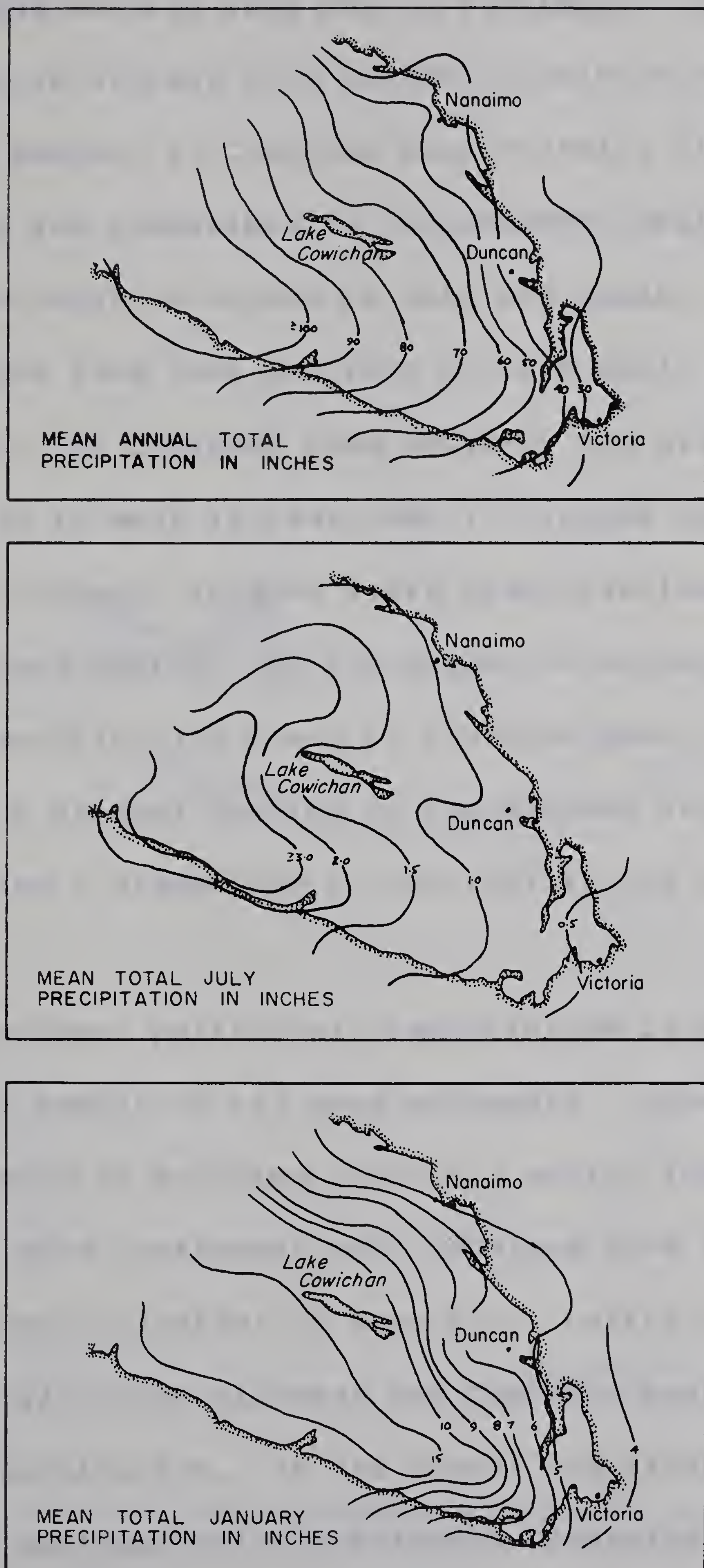
The growing season, or the average number of days with temperatures above $32^{O}F$ is one of the longest in Canada. Cowichan Bay, for twenty-seven years of record, has an average of 230 frost free days extending from late March to mid-November. For twenty-eight years of record at Duncan, the frost free period is an average of 155 days, from early May to early October. At Cowichan Lake for 17 years of record, the number of frost free days is 176,from late April to mid-October. Cowichan Bay has the greatest number of frost free days as a result of the moderating influence of the sea. Inland at Duncan, the protected hollow in which the city lies tends to trap cold air flowing down from higher elevations. Along the lowlands at the mouth of Cowichan Lake there is a longer growing season than at Duncan. The moderating influence of the lake as well as the chinook effect from air subsiding over the mountains bordering the lake accounts for this.

Total annual precipitation in the Cowichan basin is

moderate to abundant (Fig. 9). Cowichan Bay receives an average annual total of 36 inches of precipitation, Duncan 39 inches, and Cowichan Lake Forestry 76 inches. The distribution of precipitation is in north-south trending belts with the highest values at the head of the basin and the lowest at the mouth. The coastal area of the basin receives between 30 and 40 inches of precipitation a year. The annual precipitation increases to the west along the Cowichan River valley to about 75 inches at the mouth of Lake Cowichan. In the lake region the exact precipitation values are unknown. If, as stream flow records indicate, the depth of total annual runoff from the upper basin is eight feet, then precipitation in the upland areas probably exceeds 100 inches. The distribution of precipitation is the result of local relief. Therefore the greatest volume of precipitation occurs in the upland regions. Along the coastal plain, on the leeward side of the mountains, precipitation values drop off as a result of a rainshadow effect.

There is a marked seasonality in the distribution of precipitation in the Cowichan watershed (Fig. 9). The maximum occurs in the late fall and winter, December being the month with the greatest precipitation. At Cowichan Bay the average monthly precipitation in December is 6 inches, at

PRECIPITATION PATTERNS



Source: Dept. of Transport
Meteorological Division
Cir-2661 Tec-217

Fig 9

Duncan 7 inches, and at Cowichan Lake Forestry 13 inches. A summer drought extends from May to September. At Duncan and Cowichan Bay an average of 6 inches of rain is received during this period, at Cowichan Lake Forestry 11 inches, values which are comparable to the December maximum. The precipitation minimum occurs in July and August. At Cowichan Bay and Duncan less than one inch of rain falls in each of these months. At Cowichan Lake Forestry the average monthly precipitation in July is less than 1.5 inches and in August less than 2 inches. In some years precipitation may be nil in one of these months. On the graphs of average monthly precipitation (Fig. 10) there is a marked peak in December followed by a gradual decline to the minimum values of July and August, and a steep rise in the fall to the December maximum.

The seasonal pattern of precipitation in the Cowichan basin is the result of air mass movements. Showery weather is associated with Maritime Polar air moving inland over the mountains. More continuous rain develops from frontal movements or under occlusions of warm air. During the winter months frontal storms traverse the Cowichan basin bringing abundant precipitation. In the summer the fronts tend to move across northern British Columbia bypassing the Cowichan

COWICHAN RIVER BASIN

TEMPERATURE AND PRECIPITATION

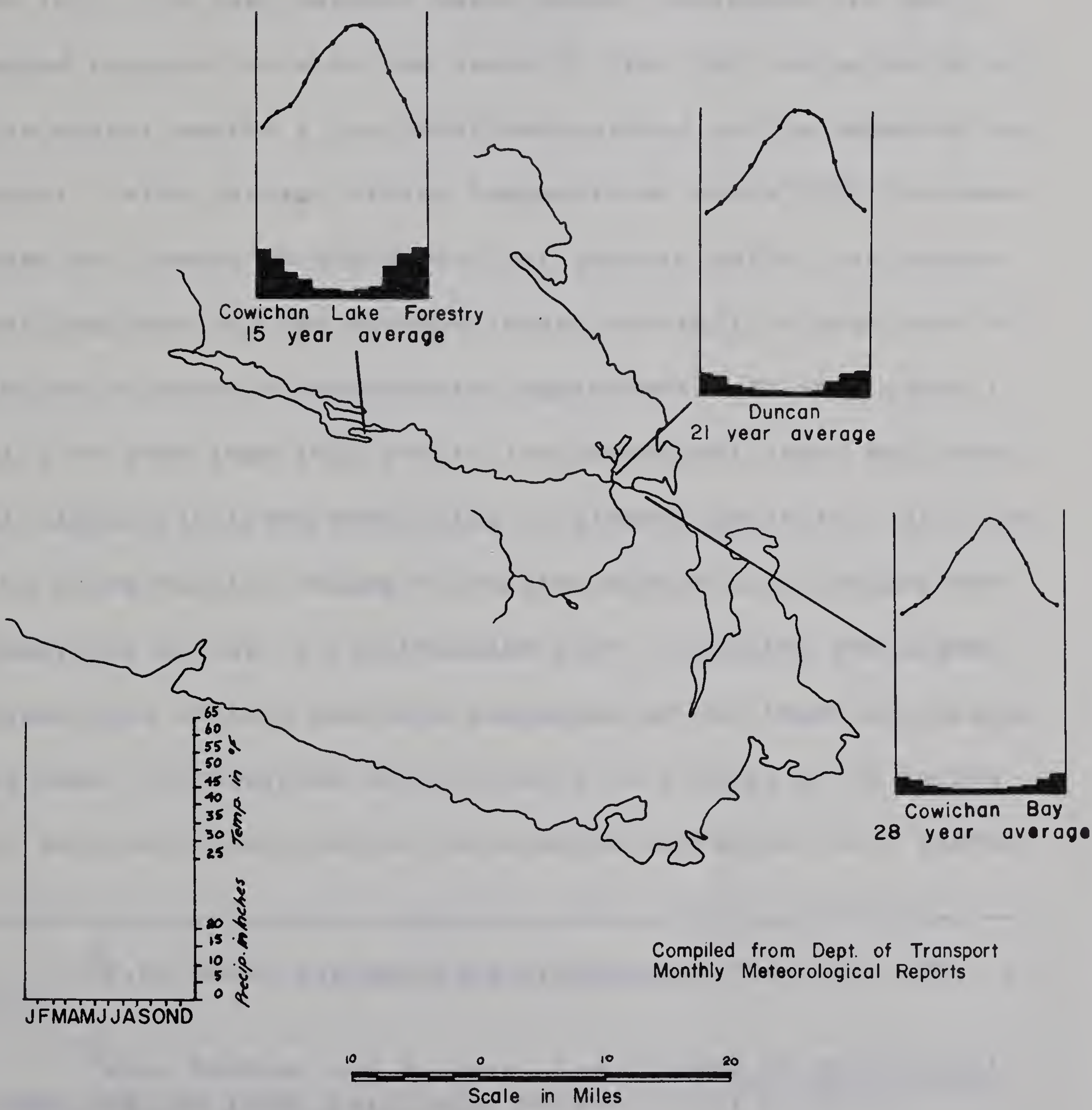


Fig. 10

valley. During this season the influence of the North Pacific High pressure system brings relatively dry, settled weather.[4]

The amount of precipitation that falls as snow in any one year is highly variable. At low altitudes incursions of Arctic air are necessary for any appreciable amount of snow to fall. In the Cowichan basin these incursions are estimated to occur once in two years.[5] Thus for the majority of the winter months a few light snow storms can be expected to occur. With average winter temperatures above 32°F the snow does not remain on the ground but quickly melts. At Duncan and Cowichan Bay the average annual snowfall is just over 20 inches or about 2 inches water equivalent. In many years it will be less than this and in the occasional year, much more. At higher altitudes snow falls in greater quantity. Air from the North Pacific during the winter months has freezing temperatures at one to two thousand feet. Crossing the higher elevations of land moisture condenses out of these air masses as snow. At Cowichan Lake Forestry an average of 70 inches of snow falls each winter, or a water equivalent of 7 inches.

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[4] F.K. Hare, The Restless Atmosphere, New York, 1961, p. 132.

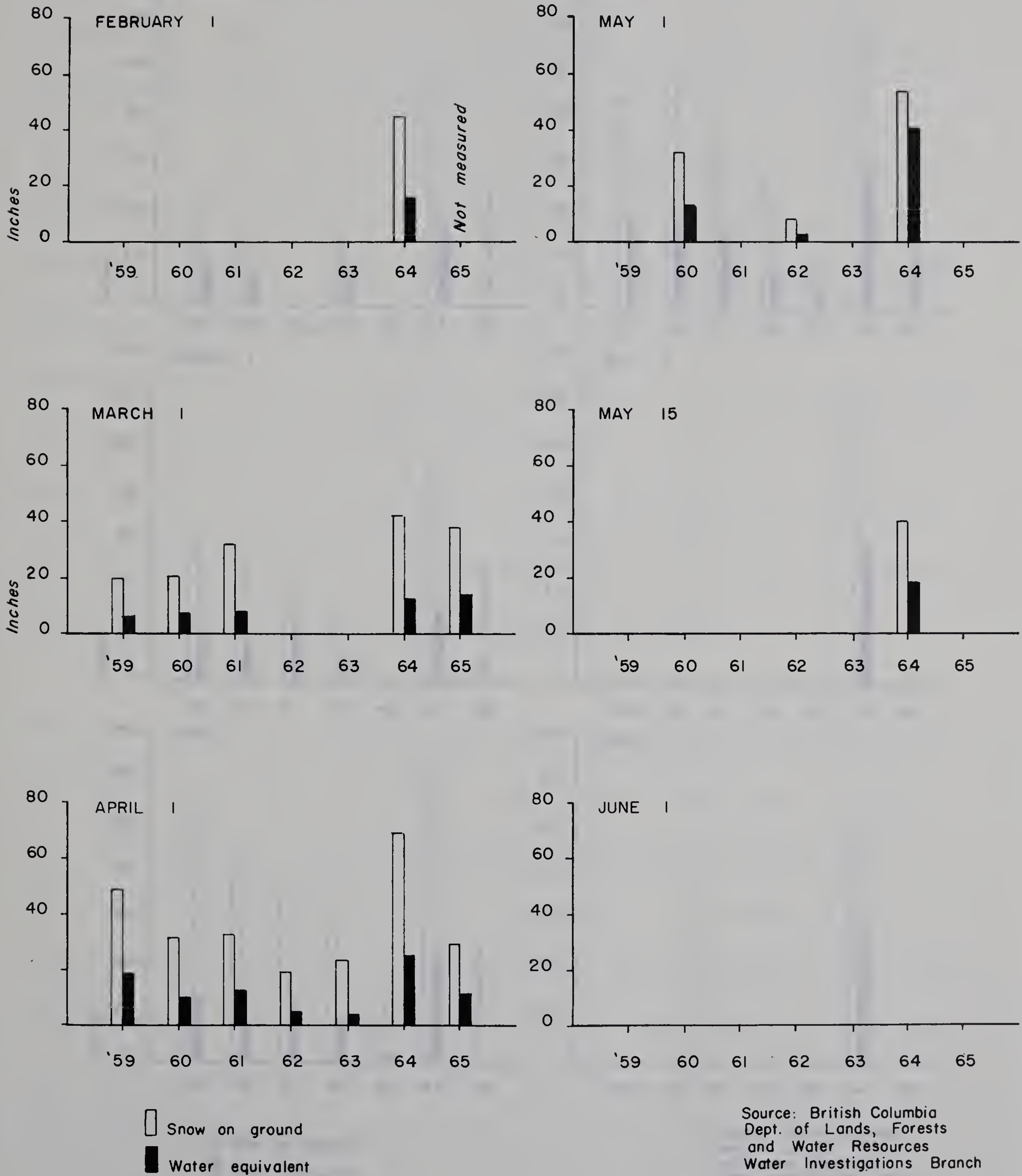
[5] W.G. Kendrew and D. Kerr, The Climate of British Columbia and the Yukon Territory, Ottawa, 1955, p. 25.

Cowichan Lake Forestry is below 600 feet so it does not really indicate snow accumulation in the mountains. There are no records tabulating total annual snow fall at higher elevations but the snow courses on Lyford and Heather Mountains provide some indication of patterns of snow accumulation and melting.

Lyford Mountain at 3,000 feet is the lower of the two snow courses. According to the records (Fig. 11) snow accumulation did not take place by the beginning of February in five out of the six years of measurement. In all but two years snow had accumulated by the first of March. After the first accumulation of snow, melting may occur with a net decrease of both snow depth and water equivalent, as in 1965. The major snow accumulation seems to take place in the latter part of March and early April. Snow melt exceeds accumulation in April and May. In four out of the seven years of record the snow was gone by the first of May. In 1965 snow persisted on the slopes until after the middle of May but it was gone by the beginning of June.

The snow course at Heather Mountain is 850 feet higher than the one at Lyford Mountain. The greater elevation is reflected in patterns of accumulation and melting (Fig. 12). The snow appears earlier, in the latter part of January and in February. In four out of the six years of record snow had

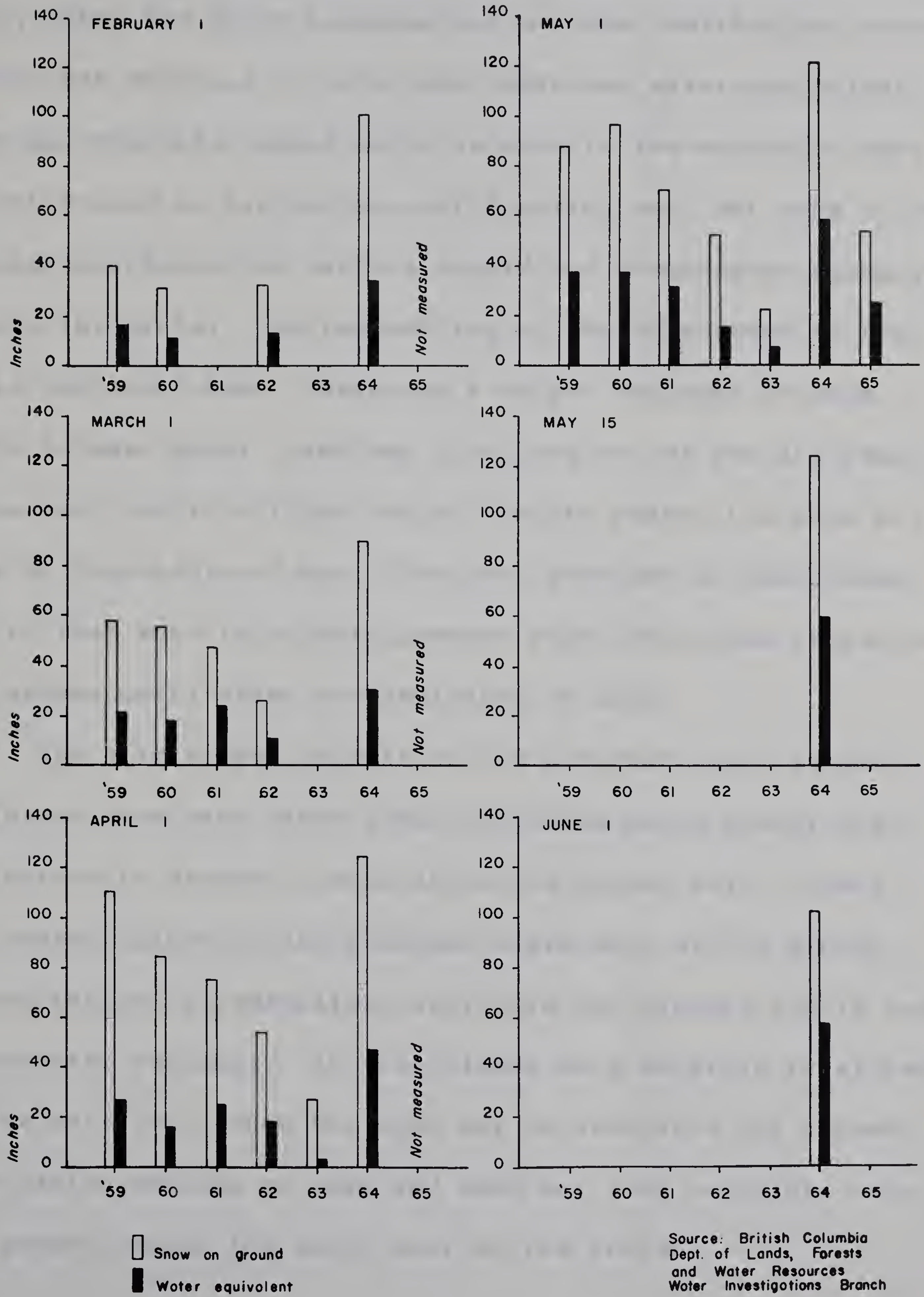
LYFORD MOUNTAIN
SNOW COURSE



Source: British Columbia Dept. of Lands, Forests and Water Resources Water Investigations Branch

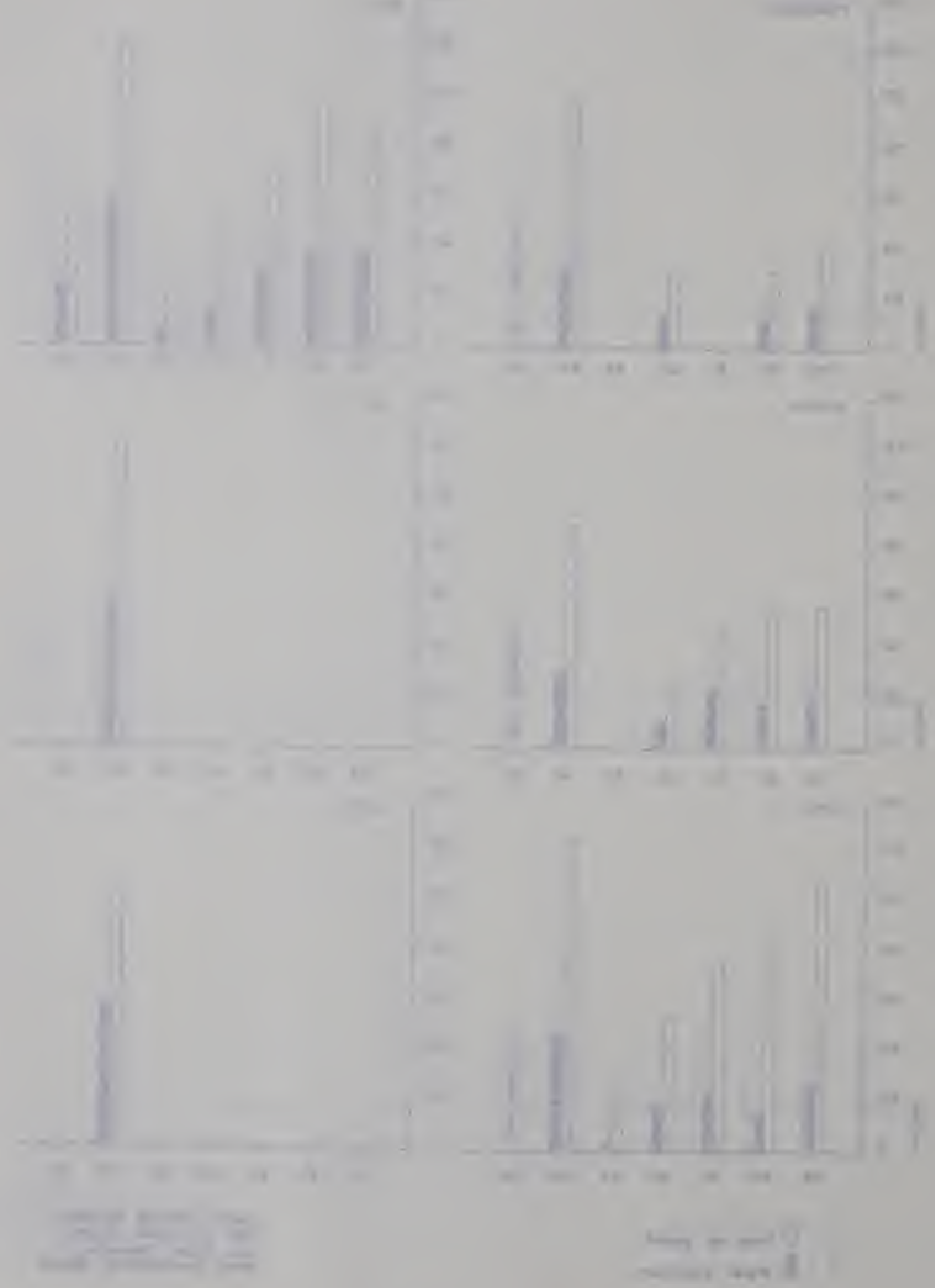
Fig. 11

HEATHER MOUNTAIN
SNOW COURSE



Source: British Columbia Dept. of Lands, Forests and Water Resources Water Investigations Branch

Fig. 12



accumulated by the beginning of February. In 1963 snow did not accumulate until sometime in March. As at Lyford Mountain, after the first accumulation of snow, melting may occur with a net decrease of both snow depth and water equivalent. Thus all the water which falls as snow in the mountain areas is not stored on the surface until spring melt but some of it becomes available for surface runoff and groundwater recharge during the winter. Spring melting of the snow seems to take place quite quickly. There was a slight decrease in snow depth between April 1 and May 1 in five out of the six years of record, and in all but one of the six years, the snow had gone by the middle of May. The year 1964 was an exceptional one in that snow to a depth greater than 100 inches stayed on the slopes until after the beginning of June.

The mild winter climate of the Cowichan basin is quite different from many other areas in Canada where winter precipitation is stored as snow until the spring melt. Along the coastal plain of the Cowichan basin most of the winter precipitation is immediately available for surface runoff and groundwater recharge. In the uplands more moisture is stored on the surface as snow but some may be available for streamflow during periods of thaw and some may even percolate into the ground during the early part of the winter.

Although the growing season is long, moisture availability during this period is low. In the lower Cowichan valley an average of 6 inches of rain is received between May and September, the major growing period. Thus without irrigation, successful cultivation of cash-crops is impeded. Pasture lands also tend to require irrigation.

The summer drought is not as serious for tree growth as it is for agriculture. Mature tree species are better able to utilize soil moisture stored at depth than are field crops. Nevertheless, young trees and seedlings with shallow root systems are at a disadvantage in establishing themselves on burnt or cutover land during the dry summer with the result that it may take several years for natural restocking to be accomplished.

The long summer season of warm sunny days and low humidity is an attraction for tourists and retired residents who seek fair weather and a comfortable climate. The mild winters, free from heavy snowfalls, are a further attraction to retired people who wish to settle in the valley.

Soils

The soils of the Cowichan drainage basin belong to the following great soil groups; Brown Podzol, Concretionary Brown, Dark Grey Gleysolic, Podzol, Alluvial, Acid Dark Brown

Forest, and Peat[6] (Fig. 13). These soils have developed from a variety of parent materials including glacial till, marine deposits, glacio-fluvial deposits, and alluvium. In areas where the terrain is stony or mountainous, or where erosion is severe, soil development has been retarded so that land types descriptive of surface conditions have been used.[7]

Detailed information on the parent material, texture, profile, drainage, permeability, moisture storage capacity, and land use capability for each soil type is contained in Appendix I. The soils have been grouped according to their parent material.

Glacial till is the dominant parent material in the basin. Shawnigan, the most common soil type, and Haslam, a minor soil type, both develop on glacial till. Shawnigan soils are found along the middle reaches of the Cowichan and Koksilah Rivers, and north of Somenos and Quamichan Lakes. The major occurrence of Haslam soil is east of Quamichan Lake and north of Somenos Lake. Both are Brown Podzols.

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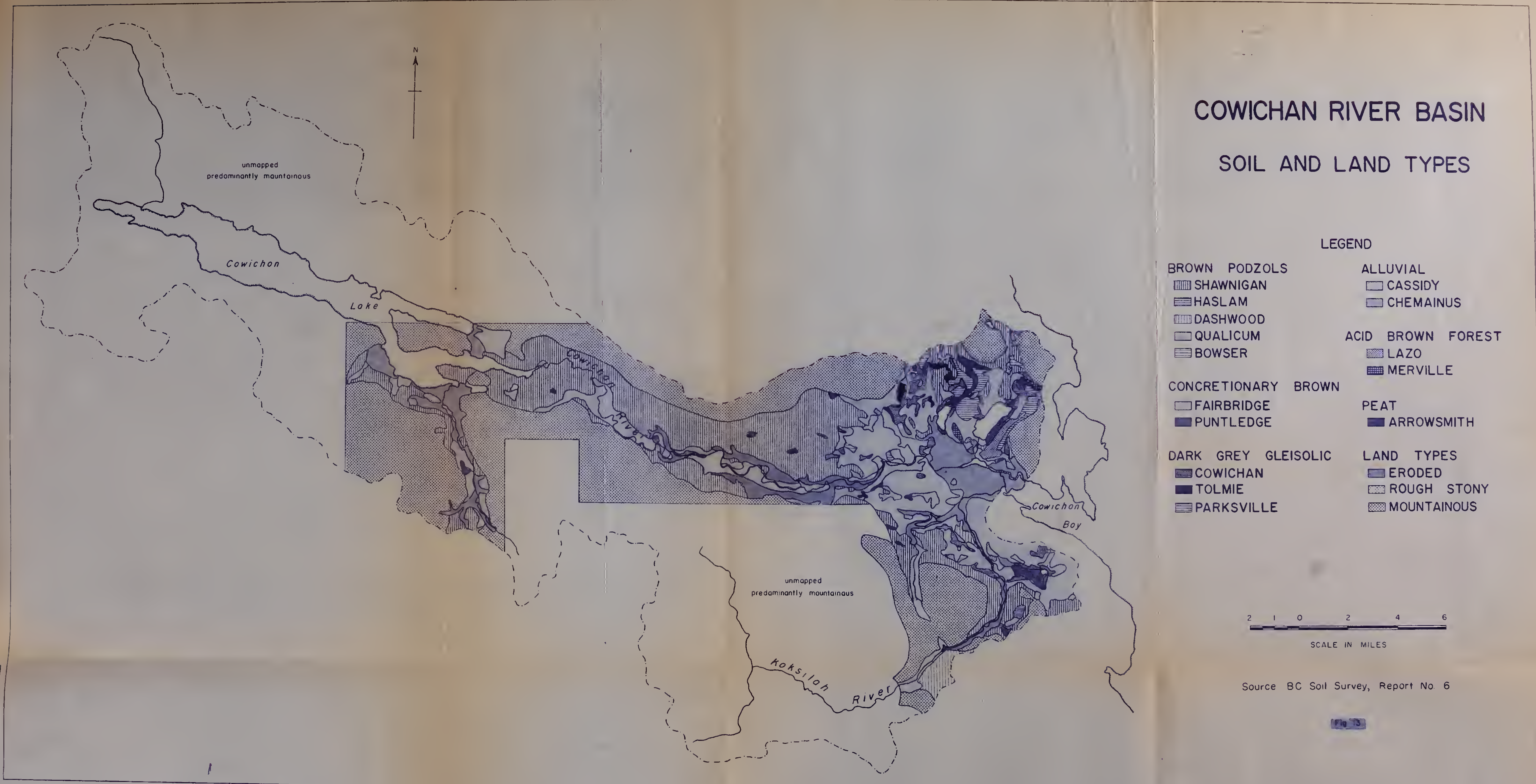
[6] J.H. Day, et al., Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia, by J.H. Day, L. Farstad and D.G. Laird, British Columbia Soil Survey, Report No. 6, Victoria, 1959, p. 32.

[7] In the Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia by J.H. Day, L. Farstad, and D.G. Laird used as the source for this section, both soil and land types are mapped.



COWICHAN RIVER BASIN
SOIL AND LAND TYPES
LEGEND
BROWN PODZOLS
SHAWNIGAN
HASLAM
DASHWOOD
QUALICUM
BOWSER
CONCRETIONARY BROWN
FAIRBRIDGE
PUNTLEDGE
DARK GREY GLEISOLIC
COWICHAN
TOLMIE
PARKSVILLE
ALLUVIAL
CASSIDY
CHEMAINUS
ACID BROWN FOREST
LAZO
MERVILLE
PEAT
ARROWSMITH
LAND TYPES
ERODED
ROUGH STONY
MOUNTAINOUS
2 1 0 2 4 6
SCALE IN MILES
Source BC Soil Survey, Report No. 6
Fig 13
N
unmapped
predominantly mountainous
Cowichan
Lake
Cowichan
River
Cowichan
Bay
unmapped
predominantly mountainous
Koksilah
River

The till tends to be bouldery with a compact D horizon which prevents downward percolation of water. The soils are stony or gravelly with a texture ranging from sandy loam to loam. They are droughty in their upper layers but saturated along the line of less permeable materials. These soils may be flooded in winter. The more elevated ones may retain moisture into the summer drought.[8] These soils are inferior for agriculture because of droughtiness and low fertility, but they are well suited to forest growth.

Marine deposits overlying glacial till or marine clay, are situated along the coastal plain. Small areas of Dashwood, Lazo, Bowser, Parksville, Merville, Puntledge, Tolmie, Fairbridge and Cowichan soil types are found on this parent material. With the exception of the relatively large concentrations of Fairbridge soils south and west of Duncan, and between Somenos and Quamichan Lakes, these soil types are scattered patches on the coastal plain. They belong to the Brown Podzol, Concretionary Brown, Dark Grey Gleysolic and Acid Brown Forest soil groups.

Marine deposits along the coastal plain are stony, gravelly, sandy, loamy, or clayey in texture depending upon

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[8] Day, op. cit., p. 26.

conditions of deposition. The soils vary in texture from clay to sandy loam, and commonly contain boulders. The marine deposits are usually shallow, resting on impervious strata of compact till or rock. Permeability is moderate to high in the upper layers of the solum, but low in the D horizon resulting in lateral movement and a perched water table above this level. The upper layers of these soils tend to be droughty. The perched water table when near the surface, produces a soil with more moisture than other soils of similar texture.[9] Soils developed from coarse textured marine deposits are generally unsuited to agriculture because of low moisture holding capacity and low fertility. They are good, however, for forest growth. Those on more finely textured marine deposits are better suited to agriculture although they may be slow to warm up in the spring and they require irrigation.

Glacio-fluvial materials are restricted to the valley of the Cowichan River. Qualicum soils are the only ones in the basin to develop on this parent material. They are Brown Podzols.

Glacio-fluvial materials are made up of gravels and sands. The resulting soils are dry gravelly loamy sand or

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[9] Ibid., p. 27.

loamy sand. Permeability is high throughout the soil layers so that they have a low moisture holding capacity.[10] This limits their use for agriculture but supports the growth of forests.

Alluvial deposits have been laid down along water courses and on deltas. The two alluvial soils in the basin are Chemainus and Cassidy. They develop on gravel and sand with the occasional veneer of loam, silt, clay or organic material. Gravelly sands tend to accumulate along the rivers. Finer textured soils are associated with the flood plain and delta deposits of the lower Cowichan. Alluvial soils tend to be subject to flooding in winter and spring. During the summer, however, the water table may drop as much as fifteen feet below the surface because of downward percolation through the coarse permeable substratum coupled with the low summer rainfall.[11] The coarse textured soils along the river banks are unsuited to agriculture but the forest growth on them is an aid in stream flow regulation and channel protection. The finer textured soils are excellent for farming where drainage is good.

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[10] Loc. cit.

[11] Ibid., p. 29.

Organic soils are limited to areas north of Somenos and Quamichan Lakes, and isolated patches elsewhere. Arrowsmith is the only soil to develop on these accumulations. It is poorly drained and moderately permeable. Unsuited to agriculture because of the difficulty of clearing and the need for drainage, it is best left under natural cover.

The land types describing surface conditions where soil has not developed are eroded land, rough stony land and mountainous land. Eroded land is situated mainly on the river banks where the soil mantle is being removed by erosion and the topography is steeply sloping. The middle reaches of the Cowichan and Koksilah Rivers, and the upper reaches of Robertson River have long strings of this land type. There are probably other small areas of eroded land along the unmapped stream courses tributary to Lake Cowichan and on the upper Koksilah River. On the coastal plain except for the banks of the major rivers there is very little erosion. The terrain is level or gently rolling and covered by vegetation, so that runoff is not rapid and the soil is protected.

More than half the basin is rough mountainous land composed of upland areas of bare rock or thin stony soils. There are a few patches of rough stony land in the basin which consist of thinly mantled bare rock or gravel. Drainage

on these lands is rapid and permeability is high. When the vegetative cover is removed from the steeper slopes of these land types, erosion by running water may be rapid. Once the thin veneer of soil is gone the reestablishment of trees may be difficult.

The soils of the Cowichan valley tend to be formed on unconsolidated materials overlying impermeable clays or bedrock. During the winter rains they may, because of the perched water table, be saturated almost to the surface. In the summer their upper layers are droughty as a result of downward percolation and reduced rainfall. The more finely textured soils on level ground are good for agriculture although irrigation is frequently necessary. The coarser soils and those on rolling or mountainous terrain are better suited to trees which can draw moisture from the perched water table and which help retain moisture on the slopes.

<u>Forests</u>

The original forest vegetation in the Cowichan basin has been modified since the first settlement by Europeans in the second half of the nineteenth century. Settlers cleared the land for farming, thus, in time, removing most of the forest cover from the coastal region of the basin. The forest industry early assumed importance in the economy.

Initially logging was carried out in the lower basin. It gradually migrated to the lake region following the opening of a road from Duncan to Lake Cowichan in 1886. Now most of the logging activity is confined to the land tributary to the lake.

Douglas fir (Pseudotsuga taxifolia) was the first species to be logged. Its great size and the large amount of clear timber obtained from it made it a valuable commodity in export trade. Douglas fir formed about forty-five per cent of the original forest.[12] It tends to grow in closely spaced stands so that a high yield per acre may be obtained. Douglas fir is a light demanding species which is found from sea level to 2,000 or 2,500 feet. It requires deep, rich, well-drained soils for the best growth but will thrive on steep, rocky sites unsuited to cedar or hemlock. Douglas fir has an average height of 150 to 200 feet and a diameter of three to six feet. Under exceptional conditions it has been known to attain a height of 300 feet and a diameter of fifteen feet.[13]

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[12] H.N. Whitford and Roland D. Craig, Forests of British Columbia, Commission of Conservation, Committee on Forests, Ottawa, 1918, p. 58.

[13] Canada, Department of Forestry, Native Trees of Canada, Bulletin 61, 6th ed., Ottawa, 1963, p. 58.

Red cedar (Thuja plicata) was the second species to be logged extensively because of the demand for its decay resistent shingles and lumber. Red cedar made up about thirty per cent of the original stand in the valley.[14] It thrives in deep, moist, porous soils on high, cool sites and in gulches. It grows singly or in patches but not in pure stands. It averages 150 to 200 feet in height and eight or more feet in diameter.[15]

Now most of the prime Douglas fir and Red cedar have been logged from the Cowichan basin. Western hemlock (Tsuga heterophylla), undercut in the past, forms the largest proportion of mature timber. Western hemlock made up about fifteen per cent of an original stand of the Douglas fir-Red cedar association.[16] This species does best on deep porous soils but it will grow on thin, poor soils if there is sufficient moisture. Western hemlock at maturity has a height of 120 to 160 feet and a diameter of three to four feet.[17]

The remaining species in the forest association formed

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[14] Whitford, op. cit., p. 58.

[15] Canada, Department of Forestry, op. cit., p. 74.

[16] Whitford, op. cit., p. 58.

[17] Canada, Department of Forestry, op. cit., p. 52.

less than ten per cent of the original stand. They are balsam fir (Abies grandis) which is found on deep, moist, well-drained alluvial soils along streams or lower slopes, and which grows to heights of 100 to 125 feet and a diameter of two to three feet;[18] Sitka spruce (Picea sitchensis) which favours deep, moist soils in valley bottoms or close to salt water, and which will attain an average height of 125 to 175 feet with a diameter of three to six feet;[19] western white pine (Pinus monticola) which is found on deep, moist, well-drained soils and on poor sandy soils at elevations up to 2,500 feet, and which has a mature height of less than 100 feet;[20] broadleaf maple (Acer macrophyllum) which prefers moist, gravelly soil[21] (Photo 3); cottonwood (Populus trichocarpa) which grows in moist soils, usually on bottom lands[22] (Photo 6); and lodgepole pine (Pinus contorta) which is found at altitudes above 2,000 feet on a variety of sites but with a preference for deep, moist, well-drained loam.[23]

Regeneration of fir and cedar on logged off areas has been generally good (Photo 10). Douglas fir is a pioneering

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[18] _Ibid._, p. 68.

[19] _Ibid._, p. 46.

[20] _Ibid._, p. 8.

[21] _Ibid._, p. 248.

[22] _Ibid._, p. 94.

[23] _Ibid._, p. 24.

species on dry, burnt and cutover land. Red cedar is a shade tolerant species which follows the establishment of a forest cover.[24] In some parts of the basin regeneration has been slow and in a few areas restocking has not taken place at all. The more exposed hillsides and the steeper slopes in particular, may remain without a renewed tree cover for a number of years.

The denudation of the steeper slopes following the introduction of trucks for logging after the Second World War, led to an acceleration of runoff and some alteration of river regime. The mature vegetation served to hold moisture in its root system, to break up the soil for greater permeability, and to return moisture to the atmosphere by evapotranspiration. The removal of this vegetation was followed by flash floods on the tributaries to Lake Cowichan and the accentuation of the peak and low flow periods on the main stem of the river. Regrowth of vegetation on these slopes has helped to stabilize streamflow characteristics again.

Erosion has in some cases, followed the logging of a hillside. The practice of skidding logs down a slope from the place of cutting to a point of assembly may leave tracks

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[24] S.A. Wilde, Forest Soils: Their Properties and Relation to Silviculture, New York, 1958, p. 255.

gouged into the soil. Subsequent runoff is then channeled into these scars further developing them (Photo 2). The construction of logging roads to facilitate movement of cut timber from a working area may also leave scars on the land which are accentuated by erosion (Photo 11). Unless checked, erosion may permanently alter characteristics of runoff and regime.

Fire is a serious hazard to forest growth. During the dry summer logging debris becomes dessicated so that it is a ready fuel. Fire has had disastrous effects on natural reproduction particularly of forest stands under twenty or twenty-five years of age. Early fire records frequently overlooked damage to these young stands as forest growth was not considered to have value until it reached log size. The destruction of twenty year old trees in a fire, however, sets back the growth by twenty-five years or more, when the period for reestablishment of vegetation is considered. The occurrence of fires in the Cowichan basin has not been widespread (Fig. 14 and 15).[25] The recent adoption of fire prevention

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[25]The most recent of the two maps of the magnitude and distribution of forest fires is the more accurate. Only fires other than the annual planned burns of logging debris have been mapped. On the earlier map both slash fires and accidental fires were mapped. In compiling a map of forest fires from this source there was some difficulty in distinguishing between the two types of fires.

COWICHAN RIVER BASIN
FOREST FIRES BEFORE 1950

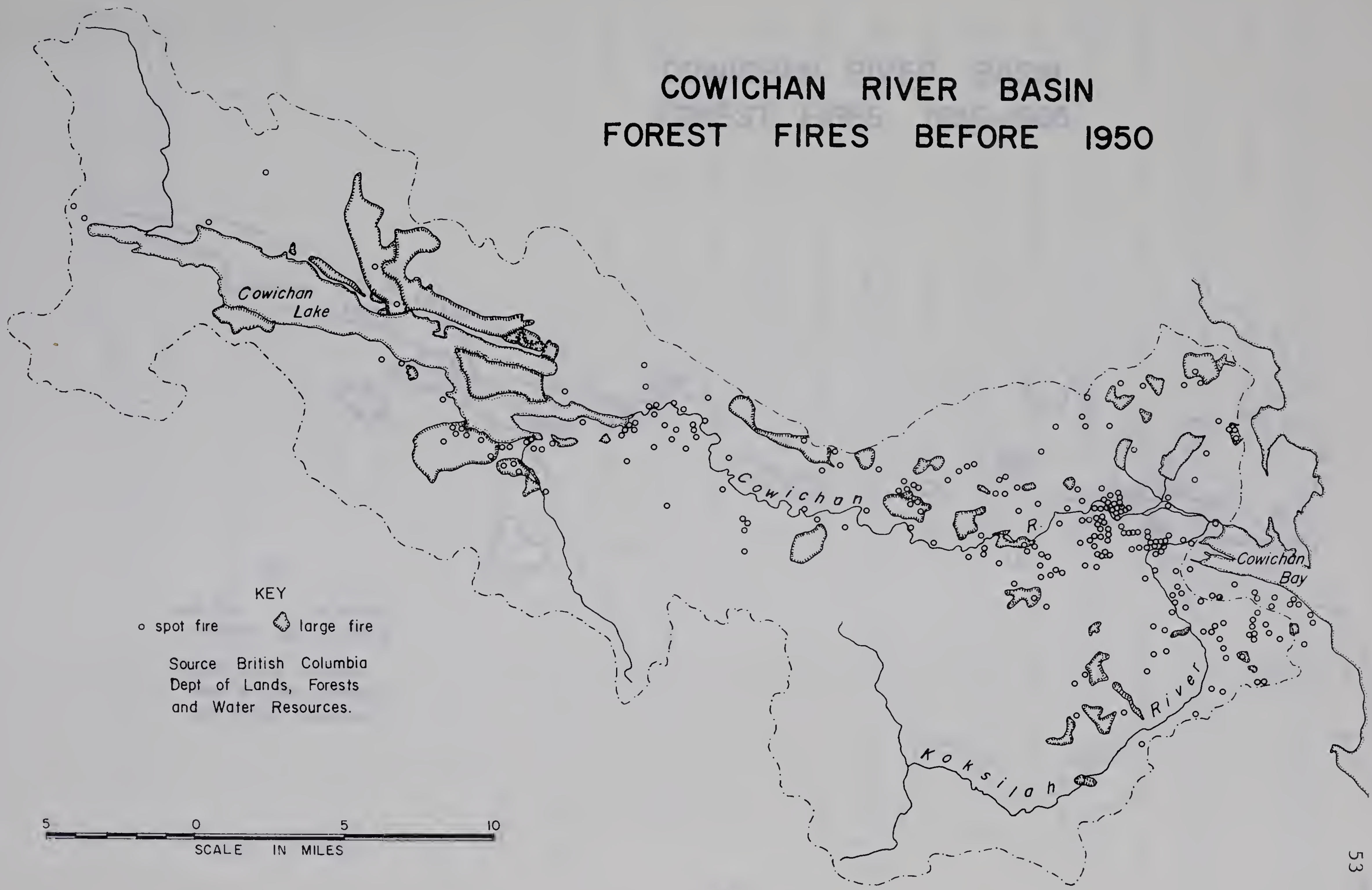

Fig 14

COWICHAN RIVER BASIN
FOREST FIRES 1950-1965

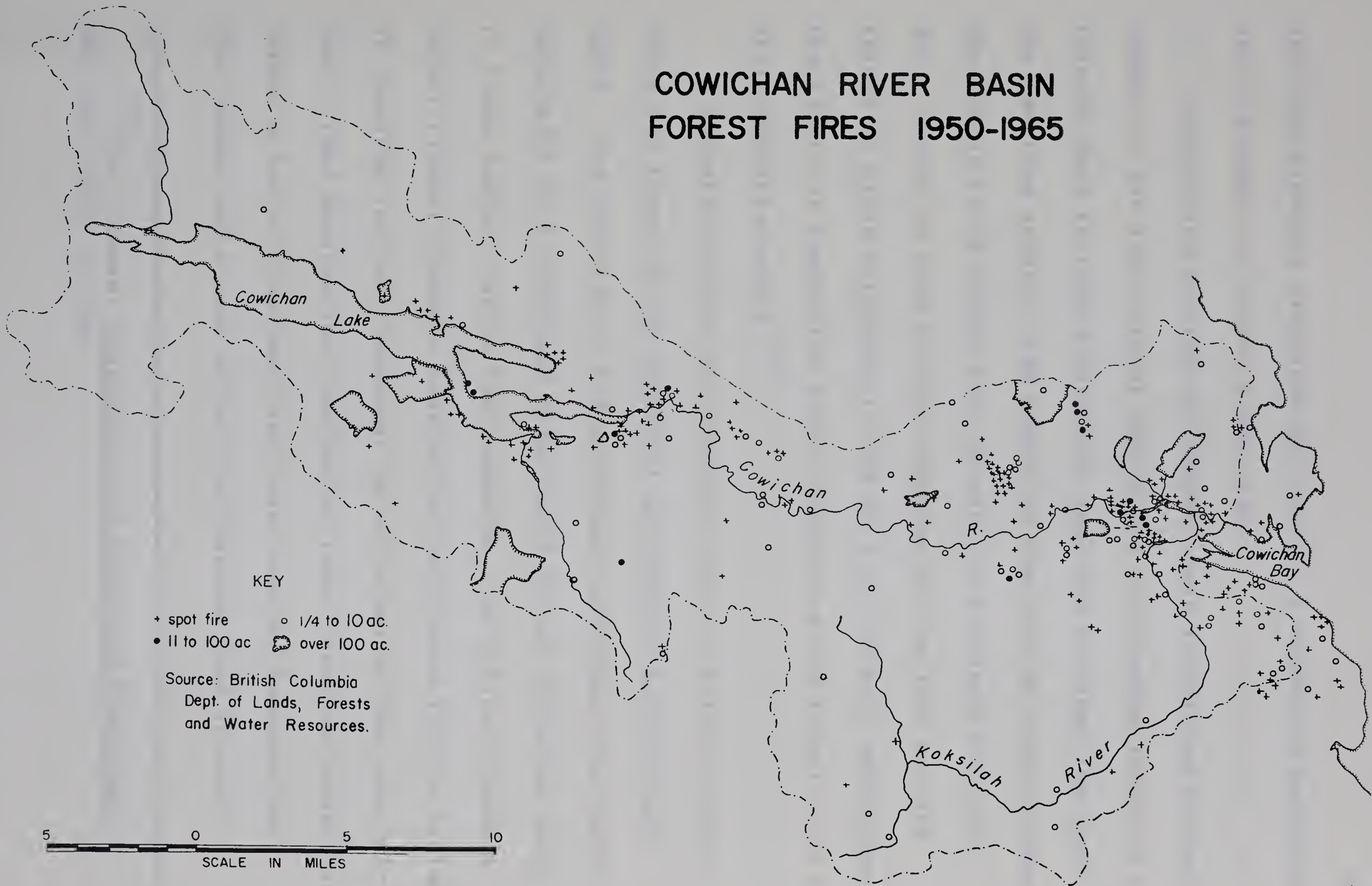

Fig 15

and fire fighting practices has further reduced the magnitude and the number of fires in the area.

Controlled burning of logging slash is carried out each autumn on the land cutover during the past season (Photo 11). This is done to remove potential fuel and to clear the land for new tree growth. The baring of the soil by slash burning may expose it to damage from erosion by accelerated runoff for a season or more but the clearing of the land and the return of plant nutrients to the soil in the ash, encourages the return of vegetation which, freed from the threat of fire, will stabilize runoff.[26]

Forested land in the Cowichan basin is held privately under the terms of the Esquimalt and Nanaimo Railway Land Grant. The policies of the provincial government for forest management on a sustained yield basis do not therefore apply to these lands. One of the companies, the British Columbia Forest Products Company Limited has had, since 1955, a system of planting two year seedlings on all areas as they are cut-over. This ensures that restocking takes place and gives the forest a two to five year start over natural regeneration. The company has a seed orchard on Cowichan Lake in which

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[26] E.A. Colman, Vegetation and Watershed Management, New York, 1953, p. 314.

experimental work is being carried out. Thus the British Columbia Forest Products Company Limited lands are being managed to preserve a quality forest cover suitable for future exploitation by the forest industry. Other companies cutting in the area are practicing sustained yield cutting to make the best use of the forest resource and to ensure a basis for continued growth.

CHAPTER III

WATER INVENTORY

In analysing the water resources of an area it is important that an inventory of the water available for use be made in as much detail as possible. Surface water and ground water must both be studied, as must the balance between water received at the earth's surface through precipitation and water removed from the earth's surface by evapotranspiration. The detail in which these may be investigated depends upon the information available. Thirty years is considered the minimum base period for hydrologic and meteorological records in the establishment of trends in water availability. None of the stations in the Cowichan River basin has a period of record of this length but several approach it. As for groundwater, there is little concrete data on location and volume of reserves although well logs and surficial geology provide some insights. The following is a generalized outline of the water resources of the Cowichan River basin.

Surface Water

Hydrology

Streamflow records were first collected in the Cowichan River basin during the First World War. Stations were set up on Cowichan Lake, the Cowichan River at the Village of Lake Cowichan, and the Koksilah River at Cowichan Station. Records were collected daily from March 1913 to September 1921 on Cowichan Lake, from March 1913 to September 1919 on the Cowichan River, and from May 1914 to March 1917 on the Koksilah River. These early stations were established to gauge the water power potential of the two rivers and the storage potential of the lake.

The collection of records lapsed for twenty years. The Cowichan River station at the Village of Lake Cowichan was re-established in September 1940, the Cowichan Lake station at a new datum in December 1952, and the Koksilah River station in August 1954. The Cowichan River station has continuous daily records to the present. At the other two stations, daily recording began in 1961. Prior to that, lake levels were measured at the Cowichan Lake station on alternate days and the Koksilah River station was maintained only during the summer. In January 1961 a station was established on the Cowichan River near Duncan. Stations on Somenos Lake, Somenos Creek, and Averill Creek commenced recording in May 1961. These eight stations (Fig. 7) have continued recording stream flow

or lake levels to the present. Data subsequent to September 1963 are unpublished and subject to revision. Flow records for Somenos Creek and Averill Creek are considered poor because of the effects of backup from the Cowichan River in times of high water.

Regime patterns for the Cowichan basin are quite distinctive (Fig. 16). The maximum flows occur from November to February, the period of heaviest precipitation in the basin. December is the month of peak flow. A gradual decrease in volume of flow which coincides with reduced precipitation values, takes place during the spring months. July, August and September are the months of lowest flows with average values being least in September. On the Cowichan River September values are only six per cent of the December peak, while on the smaller Koksilah River they are about two per cent. In the fall streamflow, augmented by autumn rains, increases rapidly to approach the winter maximum once again.

For the upper watershed, that is land tributary to Cowichan Lake, the total average monthly flow for twenty-five years of record is 590,523 cfs.[1] For the six years of record

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[1]Cubic feet per second (cfs.) is a measure of flow. The total average monthly flow can be converted to acre feet, or the volume of water required to cover an acre of land to the depth of one foot, by multiplying by a factor of 1.9835. For the upper watershed this volume is 1,171,285 acre feet.

COWICHAN RIVER BASIN

STREAMFLOW

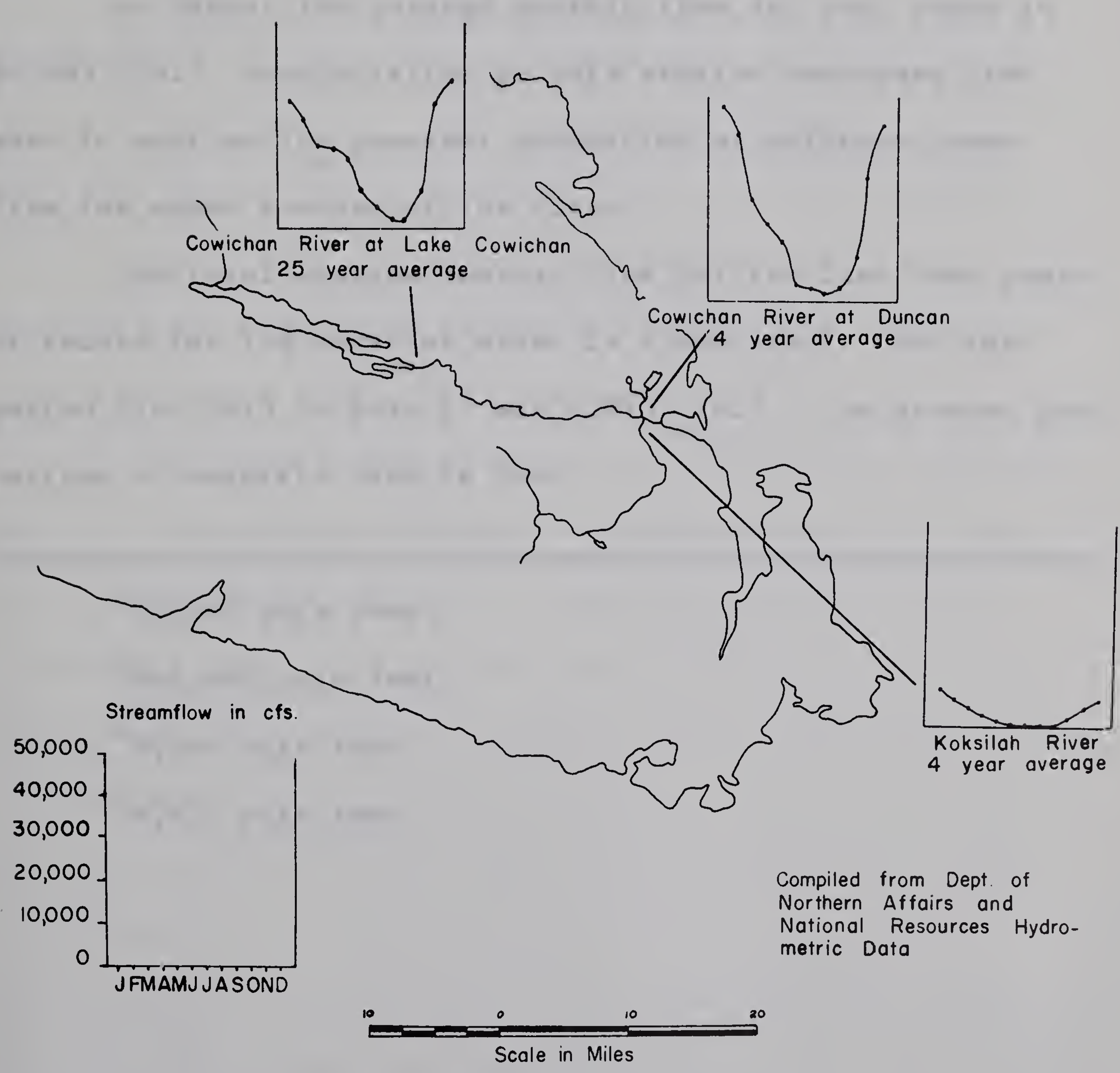

Fig. 16

between 1913 and 1919 it was 19,139 cfs.[2] The mountainous section of the watershed receives the greatest precipitation and has slightly lower temperatures than the downstream portion so it is natural that it should provide the bulk of the runoff in the drainage basin.

At Duncan the average monthly flow for four years is 22,983 cfs.[3] Precipitation in this section decreases from west to east so the greatest proportion of moisture comes from the upper reaches of the river.

The total average monthly flow for the last four years of record for the Koksilah River is 4,460 cfs.[4]: for the period from 1913 to 1916 it was 4,778 cfs.[5]. The greater proportion of mountain land in the

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[2] 37,962 acre feet,

[3] 243,936 acre feet.

[4] 8,846 acre feet.

[5] 9,477 acre feet.

Koksilah basin yields higher rates of runoff because of the greater amount of orographic precipitation.

Flooding

Flooding is of intermittent occurrence in the Cowichan valley. It usually takes the form of a flash flood which quickly reaches its peak and dissipates within a few days. The severity of flood damage depends upon the location of the overflow of water. For the most part flooding occurs on low value forest or pasture land. Only the more extensive floods affect urbanized areas and developed farm land. A few measures have been taken to control flooding but nothing of significance has passed the planning stage.

In the upper Cowichan watershed, flash floods sometimes occur in the streams tributary to Cowichan Lake which are short and of steep gradient. A heavy winter rain, often coupled with snow melt, quickly moves down the slopes in a high flow. The removal of trees on some of the steeper slopes may intensify flooding because the vegetation is not always able to reestablish itself and act as a check against rapid runoff (Photo 2). Stanley Creek had to be abandoned as a water source for the Village of Lake Cowichan when logging of the watershed altered the regime and lowered the water quality.

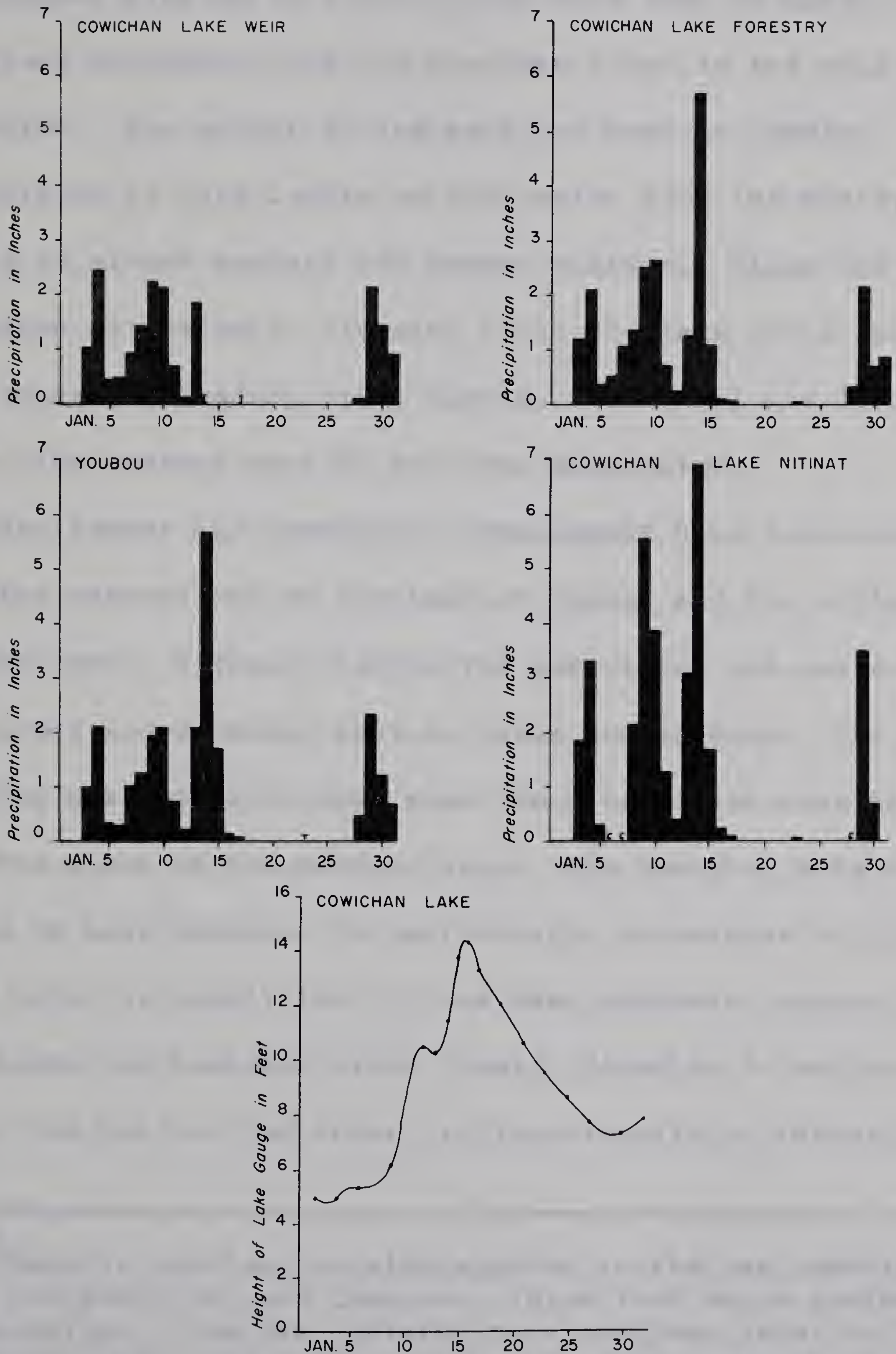
Nixon Creek poses a threat to the logging community at Caycuse as a result of flash floods in the winter. The British Columbia Forest Products Company Limited has put in a retaining wall and straightened the channel in places in an effort to promote rapid dissipation of peak flows.

Fluctuating levels along Cowichan Lake can lead to flooding. The lake is a natural storage reservoir for the flow from its many short tributaries. In times of heavy rainfall or rapid snowmelt the runoff from these streams can quickly build up lake levels to the point of flooding. In January 1961 for example, three heavy falls of rain in the first half of the month (Fig. 17) raised the lake level to flood conditions by the 14th. The January hydrograph reflects these three storms. Lake levels increased in three steps each following about a day after the three separate rainfall peaks and reaching a maximum a day after the last significant rain in the series. The drop in precipitation following each of the major storms is directly reflected in dips in the hydrograph. It would appear from these graphs that runoff from the tributaries is rapid and that there is little storage in their basins. The gradual slope of the recession curve after the last rain of the series reflects the storage action of the lake.

RAINFALL AND RUNOFF

COWICHAN LAKE

JANUARY 1961



[ ] - Rain gauge inundated
C - Cumulative readings
T - Trace of precipitation

Source Dept. of Transport Meteorological Records and Dept. of Northern Affairs and National Resources Hydrometric Data

Fig 17

In 1957 a weir[6] (Photo 12) was constructed across the outlet of Lake Cowichan by the British Columbia Forest Products Company Limited to store 32,000 acre feet of water for downstream diversion from the Cowichan River to the pulp mill at Crofton. The effect of the weir has been to reduce fluctuations in lake levels so that water from the winter maximum is stored against the summer minimum. Since the installation of the weir, flooding along the lake shore has been reduced. Flooding still occurs, as in 1961 and 1966, but for the average year it has been eliminated.

Settlement and industrial development have taken place along the eastern end of the lake at Youbou and the Village of Lake Cowichan. A small rise in the lake level can cause inconvenience and economic loss to these communities. The plant at Youbou has been shut down when the water level rose to cover the floor of the machine shop. The lowlying site of the Village of Lake Cowichan is particularly vulnerable to flood waters with the result that it has been inundated several times.

Along the Cowichan River itself, flooding is serious only at the head of the river, in the vicinity of the Village

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[6]Weir is the term locally applied to the dam constructed across the mouth of Lake Cowichan, three feet above minimum lake elevation. The dam contains four spillway gates to control flood water, six fishway slots to allow movement of spawning fish, and a boat lock.

of Lake Cowichan, and in the lower reaches east of Duncan. Along the rest of the river, either the channels are incised, preventing flooding, or no use is made of land vulnerable to overflow. In the upper reaches of the Cowichan the banks are low. Flood waters from the lake spill over into the river causing additional damage to the lowlying areas of the Village of Lake Cowichan. Control of these floods has improved since the weir was built.

Flooding occurs between Duncan and the sea. The flood plain inland from Cowichan Bay is subject to floods almost annually. Here the Cowichan and the Koksilah Rivers merge into one stream. During periods of high stream flow, when a southeast wind blows off Cowichan Bay and high tide is in, the river water piles up behind the sea water and overflows on the land. When the tide goes out the flood dissipates. The results of such a flood may be serious bank erosion (Photo 13) and the inconvenience of moving cattle. Crop loss is not usually significant as the time of submergence of agricultural land is so short that growth is not affected.[7] Flooding in this extremely lowlying area is almost inevitable. There is

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[7] Pers. Comm., Mr. K. Jamieson, District Agriculturist, Duncan.

very little, within economic reason, that can be done to alleviate it. In fact, the deposition of silt may actually enrich the soil. Measures for erosion control, however, can probably be improved.

Farther upstream from the mouth of the Cowichan and Koksilah Rivers, adjacent to the city of Duncan and the Indian lands, more serious flooding occurs at less regular intervals. Extreme high tides coupled with southeasterly winds tend to back up flows in this section of the river but this is not the most important cause of flooding. The decreased gradient and stream velocity of this reach leads to deposition of bedload and channel filling. Thus the channel capacity is too small for some of the high winter flows, so that the river overtops its banks. A Prairie Farm Rehabilitation Administration(PFRA) report on flooding in the Cowichan River cited narrow bridges and log debris as other factors impeding run-off of high flows.[8]

Serious flooding occurred most recently in 1958, 1961, and 1966 in this stretch. Damage to Indian land through erosion and pasture kill was considerable. In Duncan and in

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[8] Canada, Department of Agriculture, Prairie Farm Rehabilitation Administration, Report on Cowichan Indian Reserve Flood Control Project, British Columbia, Regina, 1958, p. 14.

the District Municipality of North Cowichan, flooding of some of the housing areas occurred so that families had to be evacuated. These floods also caused damage to the fish population of the river, diverting spawning salmon from their course, tearing eggs from the beds, and stranding fish in the fields.

Staff from PFRA, at the request of the Indian Affairs Branch, undertook a survey of the Cowichan and Koksilah Rivers to determine what could be done to prevent further damage to Indian lands. Studies were made in the summers of 1957 and 1958, and a report was issued in 1958. According to the report "...the ideal corrective measures required to minimize this flooding and erosion are, simply stated: a straight channel of even gradient and of sufficient capacity to carry the design flow and with no channel restrictions, between a point where the rivers drop into the valley floor, to the sea in Cowichan Bay."[9] Such large scale measures were not considered feasible, so recommendations for improvement of the present channels were made. The report contained recommendations for the straightening of three meanders on the Cowichan River to increase river gradient, the replacement of one bridge to reduce obstruction to flow, the diversion of the Koksilah to a new

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[9] *Loc. cit.*

channel into Cowichan Bay to minimize flood flows in the lower Cowichan, and other minor improvements.[10] The estimated cost, not including two bridge replacements, was $255,000 in 1958.

The PFRA report was accepted by the Indian Affairs Branch and the local municipal governments. The provincial government, however, did not accept it, so that full implementation could not be undertaken. The city of Duncan and the Indian Affairs Branch have tried, in the last few years, to follow the PFRA recommendations regarding channel deepening by dredging the river bed in September and building up the banks with gravel. This is an ineffective measure as a river in flood can quickly deposit enough material in its bed so that the water overflows the banks. In the 1966 flood the river broke through the elevated banks to flood the Indian reserve despite the dredging that had been done. The other recommendations for cutoffs, channel diversion and bridge replacement are too costly to be undertaken locally and so have not been implemented.

An additional flood control measure not connected with PFRA recommendations and undertaken by the city of Duncan and the District Municipality of North Cowichan, is the

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[10] Ibid., p. 6.

construction of earth and gravel dykes to stop the spread of flood flows.

In the summer of 1966 the British Columbia Water Investigations Branch undertook a new study of flood control in the Cowichan basin. Some degree of flood control does seem possible. Channel straightening and the diversion of the mouth of the Koksilah River will certainly reduce flood incidence. Flooding, however, will probably always occur on the flats at the mouth of the Cowichan River. There is also no guarantee that, whatever measures are implemented, homes in Duncan and on the Indian reserves will not be flooded.

The question of the economic feasibility of any flood control scheme is an important one. In the Cowichan valley the land most subject to flooding is on the Indian reserves. This is some of the best agricultural land in the basin but it is underutilized. The land north of the river is largely forest and unimproved pasture. The Indian band is not a farming community although it does possess about 100 head of cattle. The pasture land is mainly rented to local farmers. Because the land is leased on a short term basis there is little incentive for the lessee to improve it. Thus the potential value of the land is not being realized and an intensive expenditure to preserve it from flood damage might not

be justifiable in terms of increased returns. On the other hand, one can argue that any piece of fertile land subject to erosion as this land is, is worth preserving for future use because once gone it cannot be replaced.

The easternmost part of Duncan is the other area seriously affected by flooding. In the 1961 flood, municipal money was spent to evacuate families from part of northeast Duncan. The danger these families faced was back up from their septic tanks rather than flood waters in their homes. Since 1961 sewer services have been extended to this area so that the danger has been removed. In 1966, these houses were threatened by flood waters but evacuation was not necessary.

The periodic expenditure of money to repair minor flood damage or to evacuate families for a few days, could well be more economic than the much larger expenditure for flood control and annual improvements to the river channels. More comprehensive zoning laws whereby new buildings are restricted from flood prone areas could prevent the expansion of the built up area requiring assistance during floods. Present zoning regulations for Duncan are that new buildings in the area of the 1961 flood must be one foot above the height of that flood, or a total rise of four feet above present ground level. In the District Municipality of North Cowichan no

building regulations have been defined.

Before extensive plans for flood control are considered, study should be made of the actual need for these measures and the benefit likely to accrue to local residents from them. If a combination of zoning regulations and periodic expenditure of comparatively small amounts for repair of food damage are as effective but more economic than a large scheme requiring annual maintenance, then the emotional appeal of flood control projects for the local residents should be overlooked for the more practical solution to the local flooding problem.

Groundwater

The groundwater resource of the Cowichan valley is imperfectly known and incompletely exploited. The Groundwater Division of the British Columbia Water Investigations Branch has compiled a well inventory for the basin from interviews and the submission of well logs by drillers. The inventory is not complete, as wells were missed in the initial survey, not all drillers cooperate with the government scheme, and new hand dug wells are not reported. In many cases information collected for each well is scanty, giving location, type, and depth with only passing reference to aquifer data, yield, and water quality. Others are more detailed. In 1955 Hugh Nasmith published a paper entitled Groundwater for Farm Use

in Lower Cowichan Valley, Vancouver Island[11] which provides some insight into the groundwater resource of the basin, it is however generalized and somewhat out of date. The surficial geology of the Duncan and Shawnigan map sheets[12] was also used to gain understanding of the occurrence of groundwater.

Groundwater is exploited in two ways in the Cowichan valley, by the development of springs and by the construction of wells. Springs tend to occur near the bottom of rocky slopes or where an aquiclude is transected by a slope. Wells are developed in sand lenses, from a perched water table, or in the water table at depth. The distribution of developed groundwater is irregular in the Cowichan basin (Fig. 18). From the location of these wells, the information in the well inventory, and the surficial geology some generalization as to the groundwater resource of the area can be made.

Along the Cowichan Lake road west of Paldi, and around the lake itself little development of the groundwater resource has occurred. Population is relatively sparse along the

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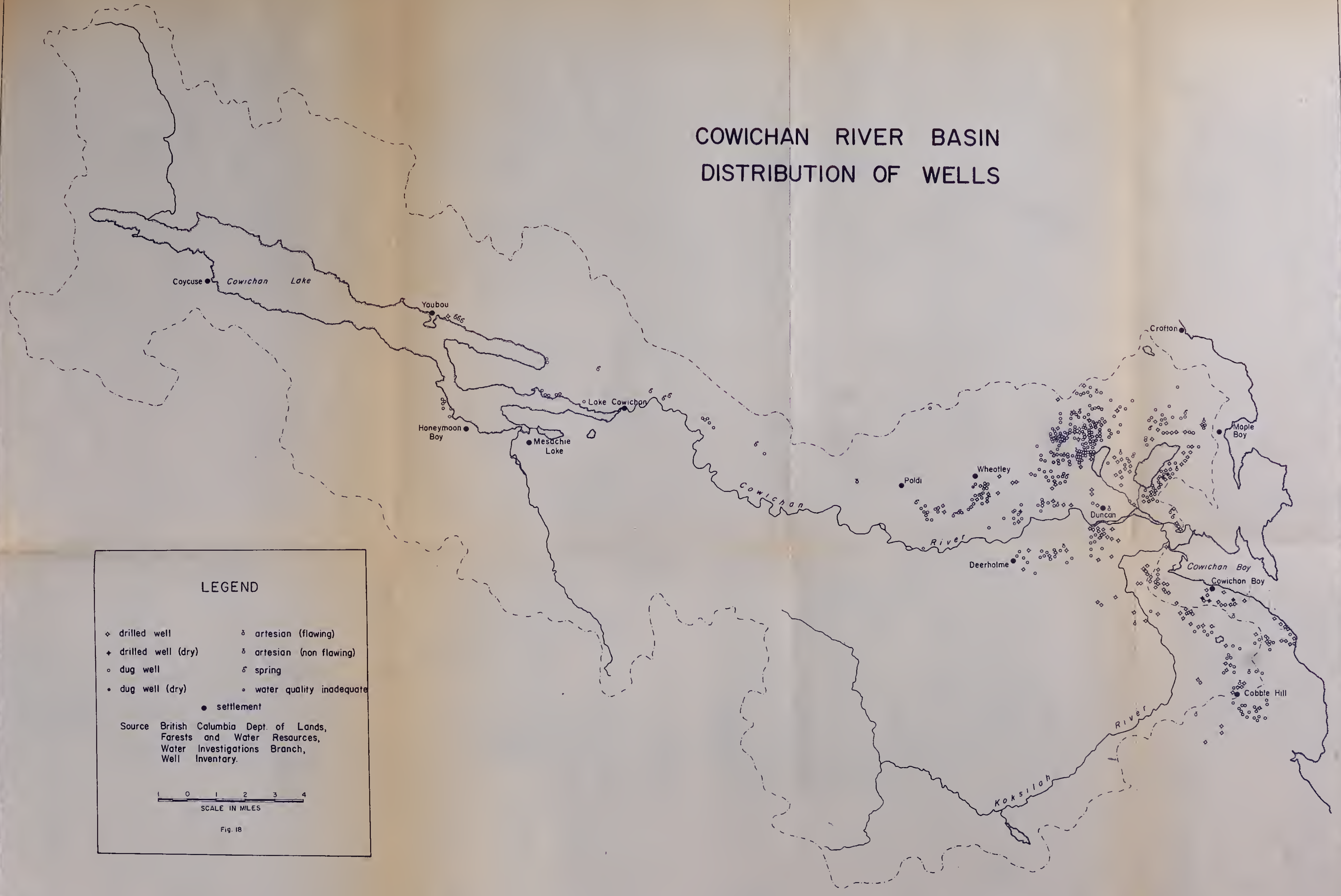
[11] Hugh Nasmith, Groundwater For Farm Use in Lower Cowichan Valley, Vancouver Island, British Columbia Department of Mines, Groundwater Paper No. 4, Victoria, 1955, 12 pp.

[12] E.C. Halstead, Surficial Geology of Duncan and Shawnigan Map Areas, British Columbia Geological Survey of Canada, Paper 65-24, Ottawa, 1966, 3 pp.

COWICHAN RIVER BASIN
DISTRIBUTION OF WELLS



LEGEND

- ◇ drilled well
- ✦ drilled well (dry)
- ○ dug well
- • dug well (dry)
- δ artesian (flowing)
- δ artesian (non flowing)
- δ spring
- ∘ water quality inadequate
- ● settlement

Source British Columbia Dept. of Lands, Forests and Water Resources, Water Investigations Branch, Well Inventory.

1 0 1 2 3 4
SCALE IN MILES

Fig. 18

Cowichan Lake road, and around the lake an organized water supply is provided for most of the residents. The wells that have been developed are shallow, less than twenty-five feet deep. They are located in ground moraine consisting of glacial till with lenses of gravel, sand and silt. Those along the lake at Marble Bay and Honeymoon Bay are probably supplied by lake water filtered through the unconsolidated material. Several springs have been developed near the bottom of the rocky valley sides in the upper section of the Cowichan Lake road, and on the north side of Cowichan Lake east of Youbou. The supply of water available in this area tends to be good. In some cases the wells service more than one household. Quantitative values cannot be set to the yields of these wells as insufficient information exists for a meaningful tabulation.

East of Paldi, in a ribbon following the road to Wheatley, there is a concentration of wells. These too are shallow, for the most part less than twenty-five feet deep, although there are a few deep drilled wells of 100 to 150 feet. In some cases the wells tap springs. The wells are found on ground moraine with the exception of a small area of fluvial deposits around Wheatley and a small area of marine deposits south of Wheatley. The wells tap groundwater sources in sand and gravel. The water yield is generally adequate for

household use.

The highest density of wells occurs west of Somenos Lake. It is here that there is the greatest concentration of rural population. Surface water supplies have been developed to their full capacity so that groundwater is depended upon as the main source of domestic water. More than half the wells in the area are less than twenty-five feet deep. There are a few drilled wells which are 100 to 150 feet deep. The surface materials in this area are marine deposits overlying ground moraine. These materials are relatively shallow so that many of the wells penetrate the shale bedrock. The shallower wells draw water from sand and gravel deposits but the deeper ones take water from fractures in the surface of the bedrock.[13] Springs can be found along the base of Mount Prevost although they are little developed.

The water supply west of Somenos Lake, according to the well inventory, is good. Many householders, however, report fluctuating levels during the dry summer season. Some have to adopt strict budgeting measures. Other wells go completely dry by late summer or early fall. Water quality is also a problem in some wells. Several households report a sulphurous

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[13] Nasmith, op. cit., p. 12.

taste or the presence of iron in their water. The iron, though not detrimental to health, may precipitate out and discolour porcelain sinks or the laundry, or clog pipes. The sulphurous taste can often be removed by boiling but in some cases, it is a deterrent to use. Both the iron and sulphur appear to be derived from the underlying shale bedrock.[14]

North of Somenos Lake along Richard Creek no wells have been developed. The surficial materials in this area are upland swamp deposits of clay, silt and peat. The land is poorly drained so that the water table is close to the surface for most of the year. The water is probably brackish from the decaying of abundant swamp vegetation.[15]

East of Quamichan Lake on the road to Maple Bay there is a second area of high density development of wells, located in marine deposits. The boundary between the marine deposits and rock outcrop loops southeast of the Maple Bay road and north of Maple Bay. Very few wells, if any appear to be located in the rock outcrop. Although there are several deep drilled wells, most of those on marine deposits are less than fifty feet deep. The overburden appears to be relatively shallow

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[14] Loc. cit.

[15] Loc. cit.

in this area as the well logs indicate that many of the wells reach bedrock. There has been a problem in developing adequate water for household use in this area as some wells are dry and others give insufficient yields. Reduced yields during the dry summer also affect many households. Most wells, however, are reported as adequate for their required use.

Between Somenos and Quamichan Lakes and also north of Quamichan Lake a lower intensity of groundwater use has developed under conditions similar to those described west of Somenos Lake and east of Quamichan Lake. The surficial materials are marine deposits. The water supply tends to be adequate although the presence of sulphur or iron is occasionally reported.

Immediately south of the Cowichan River between Deerholme and the Koksilah River, and south of the Indian reserve, a high density ribbon of wells has developed. The greatest concentration occurs west of the Koksilah. The wells are found in glacio-fluvial, marine, and shore deposits overlying fluvial materials. The wells are generally less than fifty feet deep and draw their water from sand and gravel rather than from bedrock. On the Indian reserve immediately to the north, no development of groundwater has taken place, although similar surficial deposits exist, indicating the possibility

of groundwater. The area yields an adequate quantity of water for domestic use although a few wells are reported as insufficient and a few are dry.

In the area east of the Koksilah River very few shallow wells appear to have been developed. Where there are shallow wells, water is stored in sand or gravel lenses overlying an impervious layer. The volume of water available from such wells is usually limited. Deepening of the well through the impervious layer will dissipate the existing supply rather than augment it.[16] Elsewhere water is drawn from drilled wells in sand and gravel at depths from 75 to 200 feet. Where there is extremely fine sand the well may have to be deepened to draw from a coarser material that will not clog the casing. Very few tap bedrock sources of groundwater in this area. The volume of water available from the deeper wells is variable. Many of those drilled on the bench above Cowichan Bay have been dry; others have an insufficient yield for domestic use. Most of them, however, tend to give adequate supplies.

West of the Koksilah River few wells have been developed. There are several drilled wells fifty to one hundred feet deep which have good yields. Overburden occurs in thin patches

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[16] Ibid., p. 10.

which are not conducive to extensive development of ground-water.

The groundwater resource has been patchily developed in the Cowichan basin. In many areas the water obtainable is quite adequate in quantity and quality for domestic use. In other areas, particularly west of Somenos Lake and along the Maple Bay road, there are difficulties with insufficient yields and unsatisfactory quality. Little work has been done in determining the extent or the quality of the groundwater resource. It may be that, if properly developed, the ground-water resource could service many more households

Water Balance

Water balance is a term describing the relationship between water received at the earth's surface through precipitation, and water removed from the earth's surface by evapotranspiration. Periods of surplus, when water is available for surface runoff, and periods of deficit when insufficient water is available for optimum plant growth, can be determined using bookkeeping techniques. Water balance is computed from meteorological data using the following equation:

Precipitation = (Potential evapotranspiration - Deficit) + Surplus $\pm$ Change in storage

In computing water balance, the most difficult parameter to obtain is potential evapotranspiration, the amount of water evaporated from the ground surface and transpired from vegetation given a continuous supply of moisture. The value for potential evapotranspiration may be obtained by direct measurement in field plots but there are few stations equipped to do this, and their results are frequently of doubtful accuracy. Empirical measures for calculating potential evapotranspiration have therefore been devised by several writers using climatic parameters, and a tabular and/or nomographic form of calculation.[17] These have been checked for accuracy in the field. In most cases these techniques require climatological

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[17]For a detailed review of these methods the reader is referred to:

Harry F. Blaney and Wayne D. Criddle, Determining Water Requirements in Irrigated Areas From Climatological and Irrigation Data, United States Department of Agriculture, Soil Conservation Service, Technical Publication 96, Washington, 1950, 48 pp.

M.I. Budyko, The Heat Balance of the Earth's Surface, translated from Teplovoi balans zemnoi poverkhnosti, United States Weather Bureau, Washington, 1958, 259 pp.

H.L. Penman, "Natural Evaporation From Open Water, Bare Soil, and Grass", Proceedings of the Royal Society, Vol. 193, 1948, pp. 120-145.

H.L. Penman, Vegetation and Hydrology, Commonwealth Bureau of Soils, Technical Communication No. 53, Harpenden, England, 1963, 124 pp.

C.W. Thornthwaite, "An Approach Toward a Rational Classification of Climate", Geographical Review, Vol. 38, 1948, pp. 55-94.

data that are not normally available from the standard meteorological records. Thornthwaite's 1948 procedures were used in this study because they can be readily applied to the data of temperature and precipitation available for the basin.

According to Thornthwaite's method, a heat index is obtained from mean annual monthly temperatures. This is paired with temperatures on a log-log graph to determine unadjusted monthly potential evapotranspiration. The potential values are corrected by a factor for each month which allows for varying length of day and month. The resulting adjusted values for potential evapotranspiration can then be substituted in the water balance equation.

The water balance equation provides a means for combining potential evapotranspiration with precipitation and soil moisture storage values to obtain an estimate of actual evapotranspiration. Precipitation values are obtained directly from monthly meteorological records. Soil moisture storage values are derived from information on soil texture and vegetation. When potential evapotranspiration exceeds precipitation and soil moisture storage, there is a moisture deficit with respect to the amount needed for optimum plant growth. Should precipitation and soil moisture storage exceed potential evapotranspiration, there will be a moisture surplus and

water will be available for soil moisture recharge and streamflow. The pattern of deficit and surplus for different months of the year, and from year to year, gives an empirical view of moisture relationships in an area. This, when combined with streamflow and groundwater data, completes the inventory of water yield and its seasonal and annual distribution.

In computing potential and actual evapotranspiration and the pattern of moisture availability, data have been used from the same meteorological stations as for climate. Cowichan Bay and Duncan are typical of the lower part of the basin where agriculture is practiced. Cowichan Lake Forestry represents the lower elevations of the lake region and the upper portion of the river, and can be used to interpret patterns in the upland regions of the basin.

Monthly values of precipitation and potential evapotranspiration were plotted for the three stations in the basin (Fig. 19). Values were selected to illustrate the long term average, a drier than average year, and a wetter than average year. Soil moisture storage was assumed to be eight inches. This value was chosen as being representative of the sandy loam, and loam soils under forage crops or pasture on the coastal plain, and readily adjustable to conditions of mature and immature forest in the upper basin. A complete set of water

WATER BALANCE GRAPHS

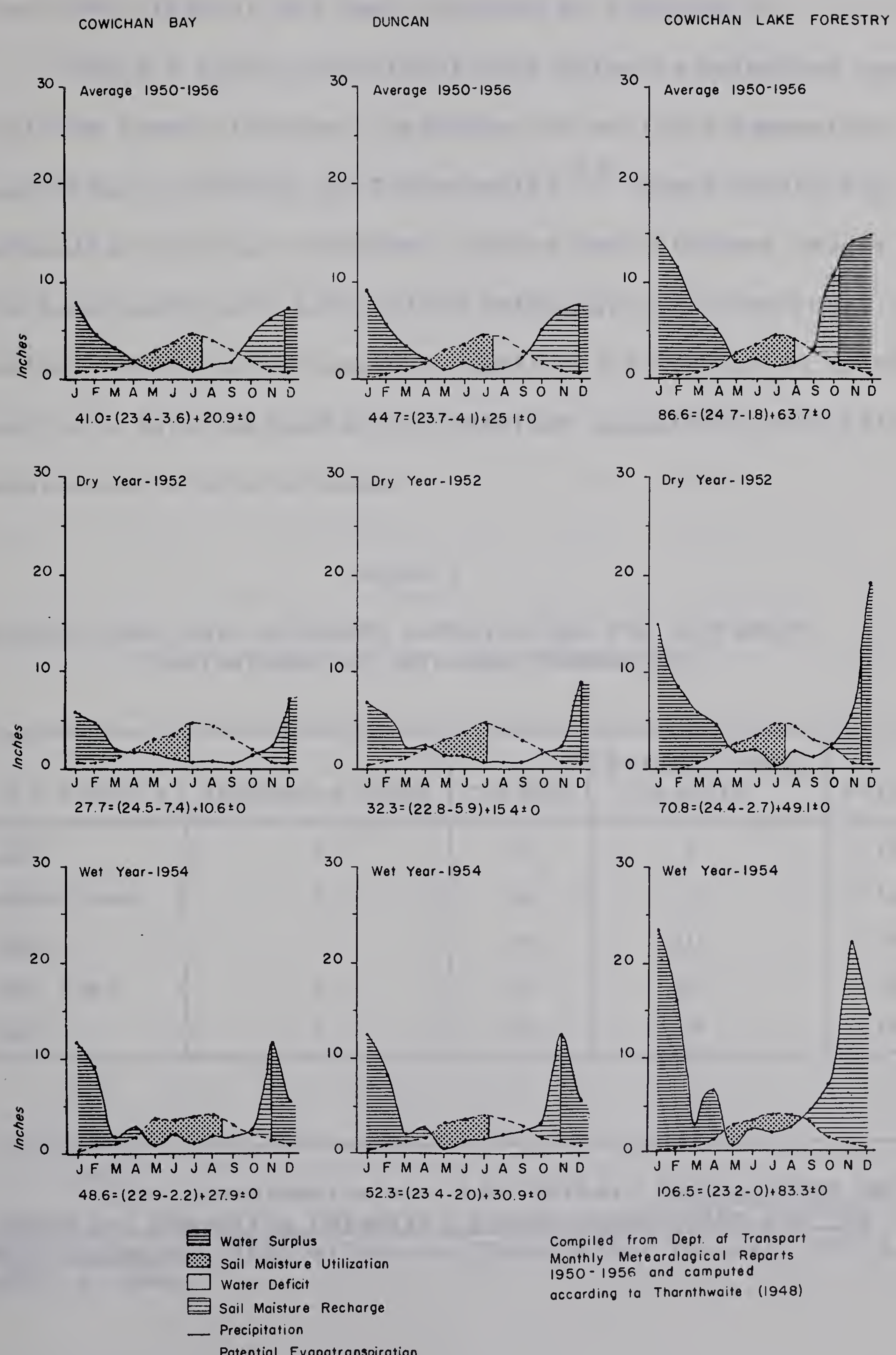

Fig. 19

WATER BALANCE GRAPHS

balance equations for the period of meteorological record at the three stations has been included as Appendix II.

Table I gives provisional soil moisture retention capabilities under different conditions of soil and vegetation according to findings by Thornthwaite.[18] These values are generalizations, as different species and different stages of the same plant will have values which may vary from those listed. Soils under immature plants and seedlings in particular, will have soil moisture retention capacities much below those under a mature cover.

TABLE I

PROVISIONAL SOIL MOISTURE CAPABILITIES FOR DIFFERENT COMBINATIONS OF SOIL AND VEGETATION

Soil Texture	Vegetable Crops	Cereals	Forage Crops, Pasture	Forest
Sand	2	3	4	10
Sandy loam	3	6	6	12
Loam	5	8	10	16
Clay loam	4	8	10	16
Clay	3	6	8	14

[18] C.W. Thornthwaite and J.R. Mather, Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance, Publications in Climatology, Vol. 10, No. 3, 1957, p. 244.

An idealized graph of moisture availability for the Cowichan River basin spanning the calendar year, would consist of a U-shape curve representing precipitation superimposed on an inverted U-shape curve representing potential evapotranspiration. The relationship of the curves to each other varies with the location of the station and the conditions of the particular year. A pattern is, however, discernible for the basin as a whole. In January and February precipitation is abundant, but waning from the December maximum. Potential evapotranspiration, suppressed by the cool temperatures of the winter season, is low during these months. During early spring, temperatures move above freezing and potential evapotranspiration increases at a steady rate. In April and May potential evapotranspiration exceeds precipitation. Initially, water needs are met by moisture stored in the soil and available to the plants at depth. In time, the soil moisture is exhausted and a water deficiency exists.[19] Actual evapotranspiration is no longer the same as potential evapotranspiration,

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[19] In Thornthwaite's 1948 procedures, deficit was assumed to commence following the exhaustion of soil moisture storage. In the 1957 procedures by Thornthwaite and Mather, it is assumed that plants use moisture in proportion to its availability. The moisture deficit therefore, is calculated as a proportion of soil moisture utilization for each month in which potential evapotranspiration exceeds precipitation. These calculations are more complicated than those of the 1948 method

but it is a value as much smaller than potential evapotranspiration as the size of the moisture deficit. Along the coastal plain, where temperatures are warm and precipitation is low, soil moisture storage is exhausted by early summer. The deficit extends through the summer and into the fall when potential evapotranspiration decreases and autumn rains recharge soil moisture. Inland, the soil moisture is adequate until late summer and occasionally throughout the summer. During most years, particularly under thin soils and shallow rooted vegetation, there is a deficit for about half the summer and into the early fall. Autumn rains, more abundant inland, quickly recharge soil moisture creating a surplus before the year is over. On the coastal plain recharge is completed near the end of the year or, on the deeper soils and in some years, at the beginning of the next. Incomplete recharge appears as a change in soil moisture storage in the water balance equation.

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and there is little difference in the total moisture deficit obtained. The water balance graphs, however, appear quite different when using the latter method, as they are constructed with a horizontal band representing deficit overlying the part of the graph representing soil moisture utilization for the entire period in which potential evapotranspiration exceeds precipitation, rather than a separation by a vertical line of soil moisture utilization and moisture deficit at some point during this period. While the 1957 procedures provide a clearer visual impression of moisture conditions, the 1948 procedures are equally valid in representing the relative volume of utilization and deficit.

The graphs of average moisture patterns are similar in their trends and monthly values for Cowichan Bay and Duncan. The curve representing precipitation matches most closely for both stations. The curve for evapotranspiration has slightly lower winter values and slightly higher summer values for Duncan as a result of its inland location. The graph for Cowichan Lake Forestry is slightly different from the other two, as there is more abundant precipitation and less evapotranspiration inland than near the coast. A detailed comparison of the moisture patterns on the lowland and in the interior reveals information about watershed characteristics and water problems under certain types of use.

The first months of the calendar year are a period of surplus for all stations. For eight inches of soil moisture storage at Cowichan Bay and Duncan there is a moisture surplus in January and February. At Cowichan Lake Forestry the surplus extends to the latter part of April. For larger values of soil moisture storage the surplus lasts as much as a month longer. For smaller soil moisture storage values the surplus period is about a month shorter.

During the winter, surplus water is available for surface runoff and groundwater recharge. The greatest contribution of moisture will be from the upper basin where

precipitation greatly exceeds potential evapotranspiration, and the time of moisture surplus is longest. Some of the precipitation in this season falls as snow and is stored on the surface until melting. At lower altitudes inland the storage period for snow is several days to several weeks, after which it melts and is available for surface runoff. At higher elevations the snow remains on the ground much longer. Patches persist in shaded hollows well into late spring. At higher elevations, therefore, precipitation received at the earth's surface during the winter surplus may not be released for surface flow for a month or more. This tends to even out streamflow in April and May when reduced precipitation should lead to a sharper drop in the stream hydrograph (Fig. 16).

In the lower basin a similar relationship exists between streamflow and moisture surpluses. The period of surplus is shorter than inland and the warmer temperatures of the coast do not allow the accumulation of whatever snow may fall in a season. Thus the contribution to surface runoff from the lower basin is more concentrated in time than inland.

Groundwater recharge takes place during this period of moisture surplus. The large surplus from the inland portion of the basin ensures good year-round supplies of groundwater in that area. Some of the groundwater may flow down the

eastern slopes of the mountains to supply aquifers in the western part of the coastal plain. For the rest of the lowlands the smaller volume of soil moisture surplus may not provide adequate groundwater recharge to last through the summer drought.

Early in April potential evapotranspiration exceeds precipitation on the coastal lowland. From April until early July potential evapotranspiration is maintained by withdrawal from soil moisture storage. Once the soil moisture storage is exhausted, a condition of moisture deficiency exists. On land with less soil moisture storage than the aforementioned eight inches, the deficit is felt in May of most years. For deeper soil moisture storage the deficit is postponed until August because of the greater moisture available to offset potential evapotranspiration. Inland, precipitation is adequate to meet the demand of potential evapotranspiration until late in April. Soil moisture storage is not usually exhausted until late in August. Under conditions of shallow soil moisture storagethe deficit may appear in June, or perhaps in May. Where there is deeper soil moisture storage, there may be no deficit at all, or a small one in September.

During the spring and summer, contributions to streamflow

come mainly from precipitation into surface water bodies, and base flow from groundwater storage. Except in heavy rainstorms when surface detention storage is filled, there is no moisture surplus. Because of differences in precipitation the contribution to streamflow from the upper basin remains larger than that from the lower basin. In both areas streamflow is at its lowest. Groundwater storage is also being depleted at this time and may in some areas be completely exhausted.

Patterns of soil moisture utilization and deficiency have an important effect upon the vegetation of the Cowichan basin. The upland area is the most favoured for vegetative growth. Soil moisture utilization commences toward the end of April. For mature trees soil moisture is usually adequate throughout the dry season. For vegetation on shallow, permeable soils, and vegetation with less mature root systems, a deficit may be felt in August or in July. Young trees and seedlings experience a soil moisture deficit as early as May, just after the growing season has begun, and must depend for their growth upon whatever precipitation falls throughout the summer. In exposed areas such as a burn or a clear cut patch, seedlings may have difficulty surviving the summer drought. On more sheltered sites the ground is protected from early dessication by tall shade trees. To overcome the difficulty of restocking

in clear cut areas the British Columbia Forest Products Company Limited has adopted the policy of planting two year old seedlings which were transplanted in the nursery after one year. These are found to have better developed root systems, an asset to the seedlings in their first years of growth, than seedlings which have not been transplanted in the nursery.

In the lower part of the basin moisture conditions are such as to impede vegetative growth, particuarly for agriculture, except on favoured sites or under irrigation. Mature trees are best able to withstand the summer drought. They have well developed root systems which, when in porous soils, can utilize soil moisture for a month longer than more shallow rooted species on less favourable soils. Nevertheless, the summer drought probably impedes tree growth in most years. The eight inches of soil moisture storage illustrated in the graphs represents conditions prevailing for forage crops or pasture on sandy loam or loam soils. A deficit exists for these crops from midsummer to early fall, a period spanning almost half the growing season. Soil conditions may vary but plant growth during this period is uniformly below optimum levels. Farmers report that, without irrigation, they must start feeding their cattle hay by the beginning of July, as the pasture is too dry to use. A deficit near the beginning of the growing season means that newly sown crops will not

yield as high returns as those sown in a more favoured environment or those under irrigation. Thus the condition of summer drought tends to raise the cost of agricultural production in the basin, either through the necessity of buying cattle feed early in the season, or of installing irrigation systems.

The autumn rains narrow the gap between precipitation and potential evapotranspiration. In September at all three stations precipitation exceeds potential evapotranspiration. A moisture surplus exists which may be applied to soil moisture recharge. When soil moisture recharge is completed the surplus is then available for surface runoff. In the upper basin, soil moisture recharge is completed during October for all storage values in most years. This is reflected in the streamflow characteristics of the upper basin. The upward trending limb of the stream hydrograph following the autumn rains when soil moisture recharge is taking place, is not as pronounced as is the curve for precipitation. Between October and November there is a sudden steepening of the curve when surplus moisture is released as surface flow (Fig. 16).

In the coastal lowlands, moisture recharge for eight inches of storage is not completed in most years until

December. Under the dry conditions of some years moisture recharge continues into the first month of the new calendar year. Where soils are thin or vegetation is shallow rooted, there is some surplus moisture for surface runoff during the fall and early winter. For areas with a larger storage capacity a moisture surplus is not available until December or January.

Some mention should be made of moisture patterns for individual years. Data from 1952 have been chosen to illustrate conditions at the three meteorological stations on a drier than average year. A wetter than average year is represented by the year 1954.

In 1952 precipitation was close to average during the winter at the three stations. During the spring and summer, however, it was below average. At the same time potential evapotranspiration was slightly higher than average. As a result of this combination of conditions, soil moisture utilization began slightly earlier than usual and a deficit emerged early in July at Cowichan Bay and Duncan, and by the middle of July at Cowichan Lake Forestry. Precipitation in the fall lagged behind the usual values so that soil moisture recharge did not proceed as rapidly as in other years. At

Cowichan Lake Forestry recharge was more than a month later than the average, at Duncan and Cowichan Bay it was a few weeks later than usual.

In 1954 precipitation was above average in January and February for all three stations. During the spring and summer, precipitation seemed to alternate between values above and below normal. Despite the peculiar fluctuation of rainfall, the commencement of soil moisture utilization and of moisture deficiency at Cowichan Bay and Duncan occured at about the usual time. At Cowichan Lake Forestry, the above average rainfall in July and August eliminated the moisture deficit altogether. Potential evapotranspiration was below normal during the summer, which aided in reducing the moisture deficit for that season. Precipitation in the early fall was close to average values. November rainfall was abnormally high, with the result that soil moisture recharge at Cowichan Bay and Duncan was completed a month earlier than usual. At Cowichan Lake Forestry, in addition to the high November precipitation there was a larger than average surplus recorded because of the absence of the need to replenish soil moisture storage at the end of the summer.

A more detailed impression of the annual distribution

of deficit and surplus is presented in a series of graphs (Figs. 20 to 25) in which moisture deficit and moisture surplus for six different storage values (one, two, four, eight, ten, and twelve inches) were plotted for the period of common record, 1950 to 1956, of the three stations for which evapotranspiration was computed. To illustrate the moisture deficit, four months, April, May, July and October, were chosen from the six to seven month deficit period to represent conditions at the beginning of the summer drought, at the peak of the drought, and at the end. Four months of moisture surplus, November, December, January, and March, were chosen to represent conditions at the beginning of the winter surplus, during the surplus both at the end of one calendar year and at the beginning of the next, and at the end.

During April on the coastal plain a deficit appears in the occasional year for the lowest soil moisture storage values. By May there is a emerging deficit for the lowest storage values. During July all the soil moisture storage has been exhausted for these lower values with the result that vegetables and other shallow rooted crops must depend upon local rainfall for their moisture supply. This situation is intensified until the autumn recharge begins. In October there may be no deficit or a much reduced one.

Inland, the period of moisture deficit is shorter than

MOISTURE SURPLUS

COWICHAN BAY

1950-1957

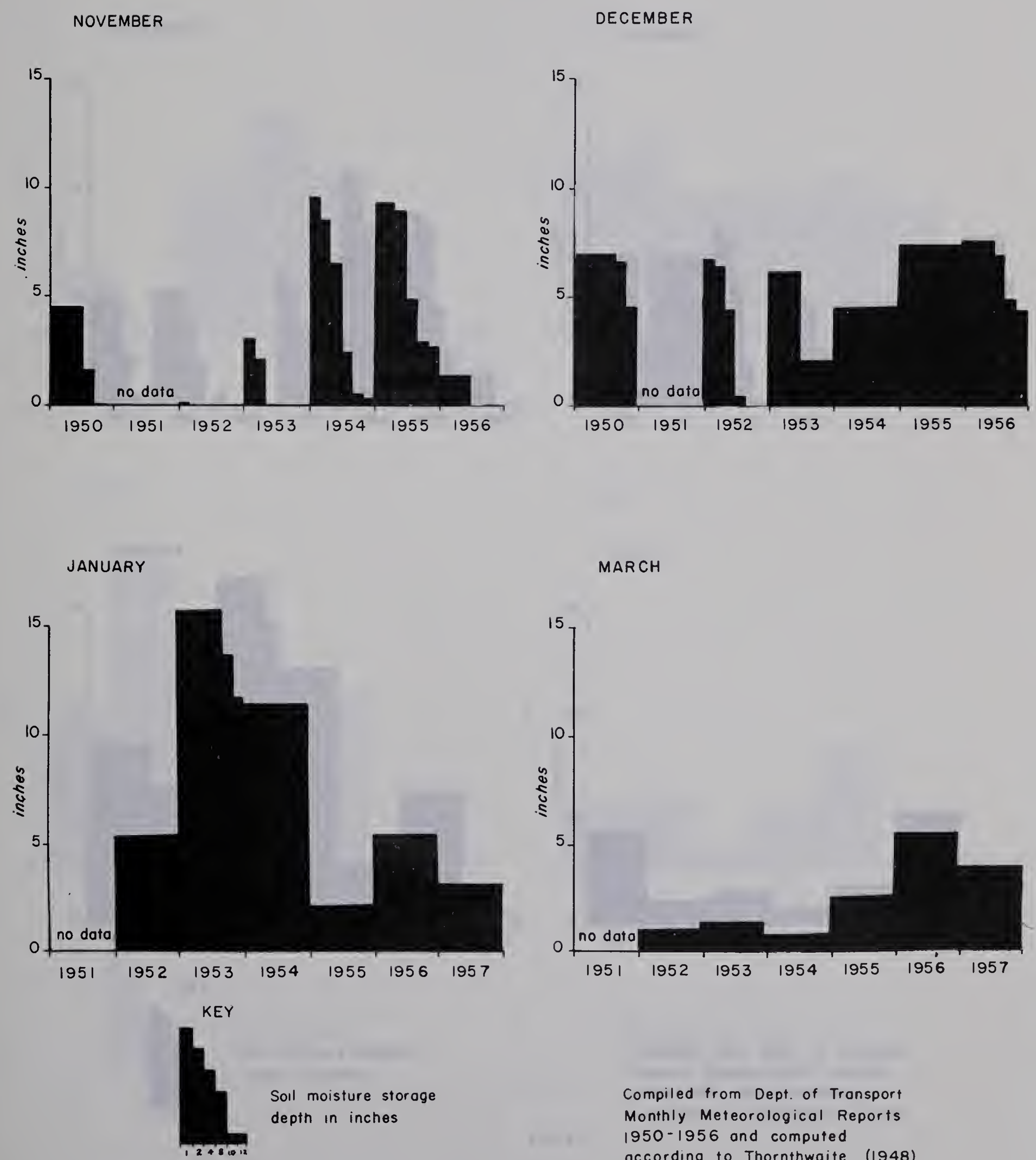
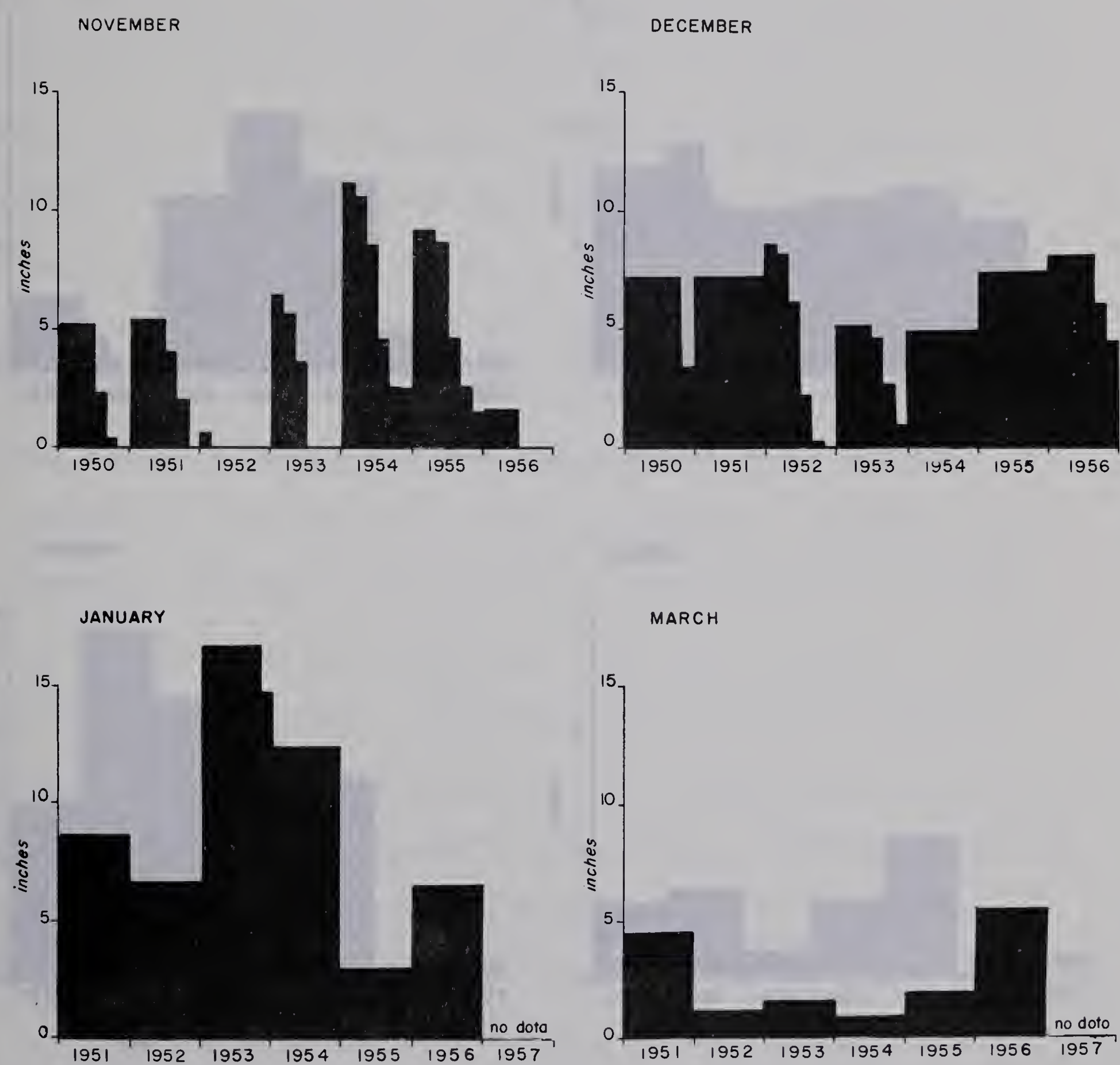


Fig. 20

MOISTURE SURPLUS

DUNCAN

1950-1957



KEY

Soil moisture storage depth in inches

Compiled from Dept of Transport Monthly Meteorological Reports 1950-1956 and computed according to Thornthwaite (1948)

Fig. 21

MOISTURE SURPLUS

COWICHAN LAKE FORESTRY

1950 - 1957

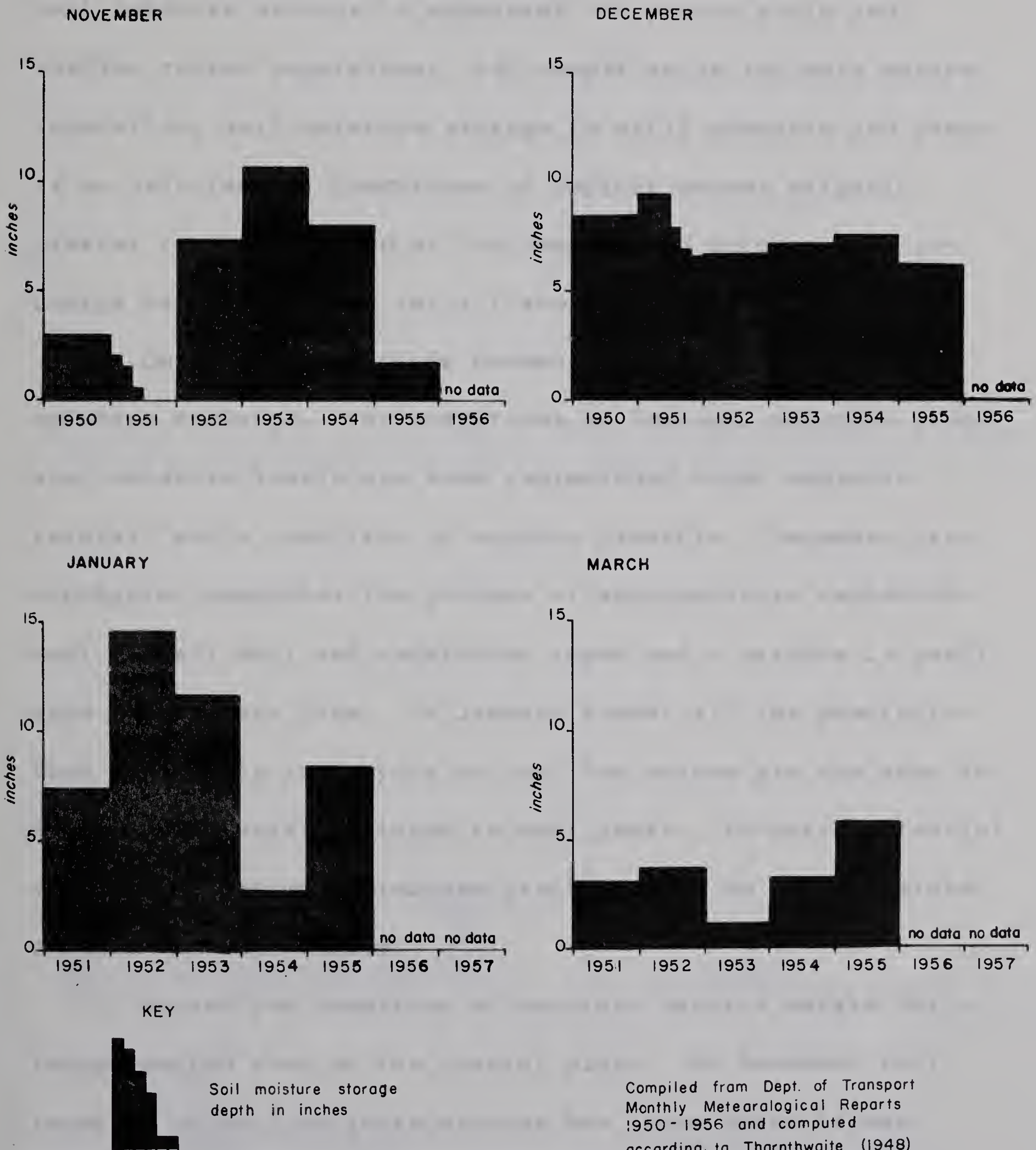


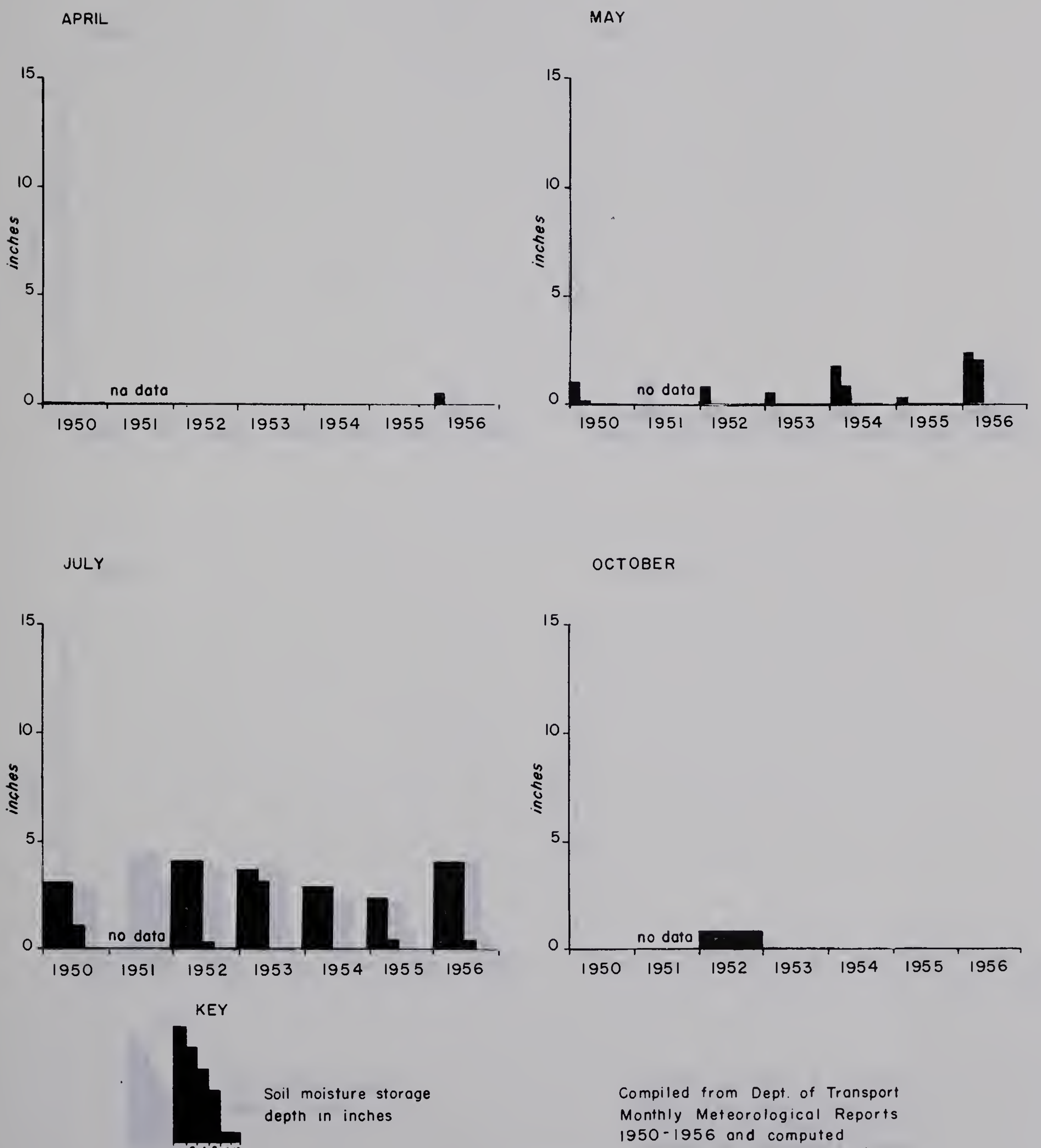
Fig. 22

on the coastal plain. The first deficit for the lower values of soil moisture storage does not appear until May. By July soil moisture storage is exhausted for porous soils and shallow rooted vegetation. For deeper soils and more mature vegetation, soil moisture storage is still adequate and there is no deficiency. Conditions of deficit become slightly greater towards the end of the summer. By October full recharge has taken place for all storage values.

On the coastal plain November is the month of soil moisture recharge. For conditions of low soil moisture storage, moisture levels are soon replenished under moderate rainfall and a condition of surplus prevails. December precipitation completes the process of soil moisture replenishment for all soil and vegetation types and a surplus is available for surface flow. In January almost all the precipitation that falls is surplus so that the values are the same for all soil and moisture types in most years. In March potential evapotranspiration approaches precipitation so that moisture surplus is much reduced.

Inland the condition of moisture surplus exists for a longer period than on the coastal plain. By November full recharge of soil moisture storage has taken place in most years and all the precipitation received is available for surface runoff under all conditions of soil and vegetation.

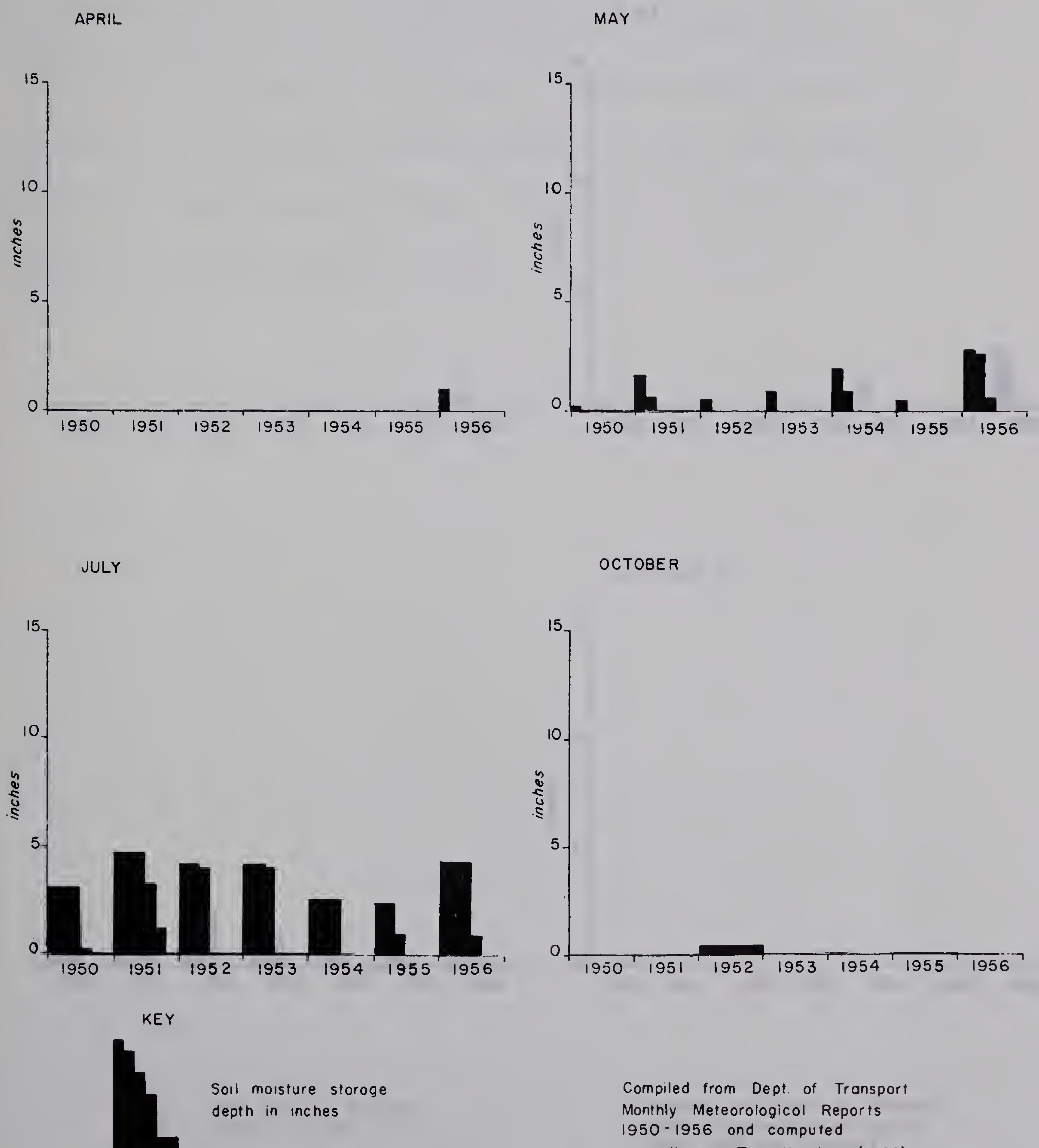
MOISTURE DEFICIT
COWICHAN BAY
1950-1956



Compiled from Dept. of Transport Monthly Meteorological Reports 1950-1956 and computed according to Thornthwaite (1948)

Fig. 25

MOISTURE DEFICIT
DUNCAN
1950-1956



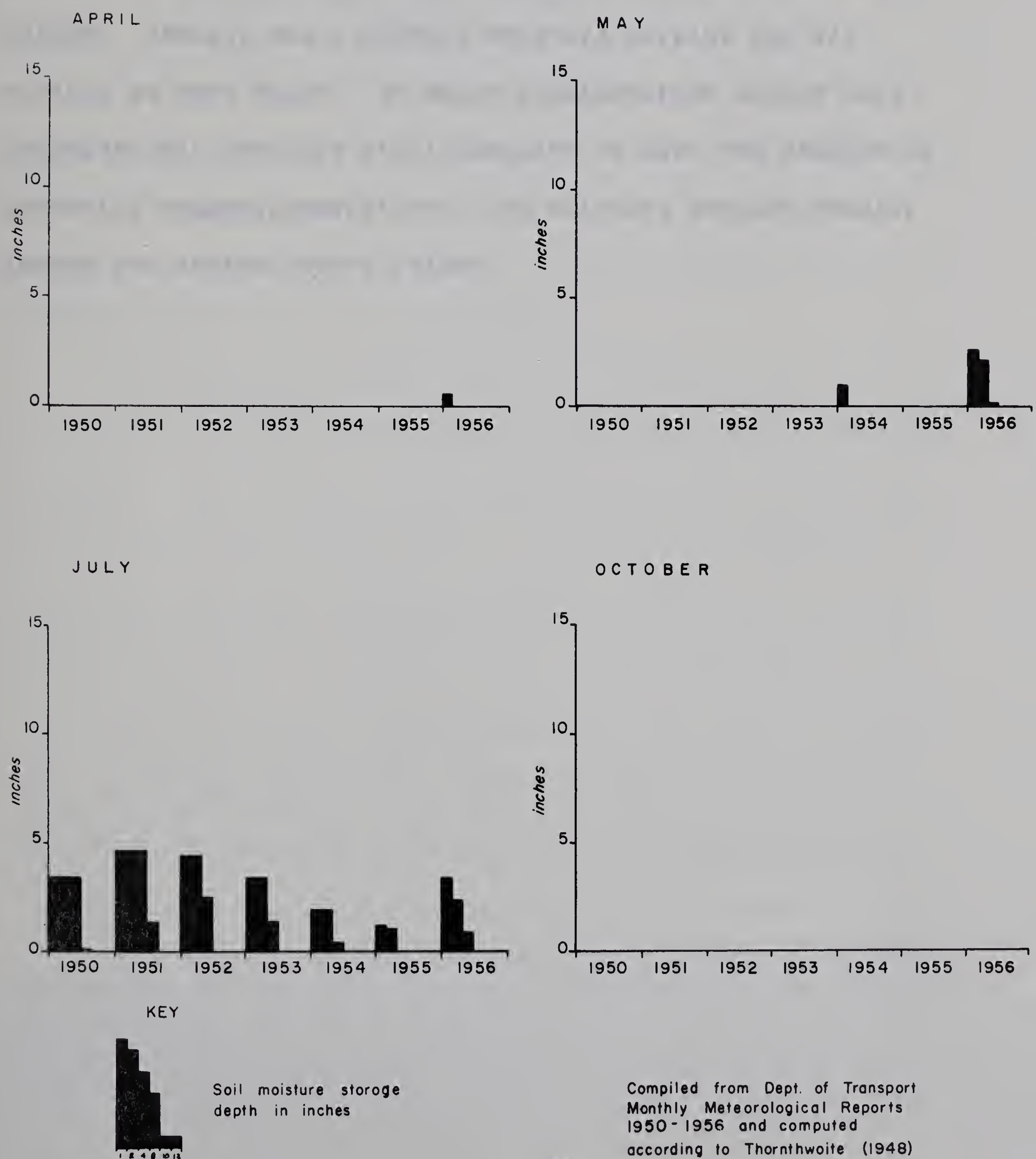
Compiled from Dept. of Transport Monthly Meteorological Reports 1950 - 1956 and computed according to Thornthwaite (1948)

Fig. 24

MOISTURE DEFICIT

COWICHAN LAKE FORESTRY

1950 - 1956



Compiled from Dept. of Transport Monthly Meteorological Reports 1950 - 1956 and computed according to Thornthwaite (1948)

Fig. 25

In December too, all of the precipitation is available for surface runoff, except in an odd year of slow recharge in which there would be a reduced surplus for larger storage values. January has a uniform moisture surplus for all months, as does March. In March precipitation values have decreased but they are still adequate to meet the demands of potential evapotranspiration. The moisture surplus usually lasted for another month inland.

CHAPTER IV

WATER UTILIZATION: PRIMARY USES

Water utilization is the keynote of a water resources study. It is through a consideration of the apportionment of water and trends in water uses in a basin, that potential problems of demand, and conflicts between demands can be identified and their solutions proffered.

In the Cowichan River basin the greatest proportion of water utilization is for domestic, waterworks[1] and industrial purposes. Agriculture, mining, power, fish, wildlife, recreation and navigation, the other traditional categories of water use, are much less significant in terms of actual volume of water used and will be dealt with in the next chapter.

Industrial water use accounts for the largest consumption of water in the basin. About 60 million gallons are withdrawn per day for use primarily in the forest products

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[1]The term waterworks refers to an organized water supply system operated by a municipality, an improvement district, or an individual. Although the water may be used primarily for domestic purposes it is distinguished from the category of domestic use by the greater number of residents using the one system and the possibility of commercial and industrial use.

industry.[2] About two million gallons are used each day in organized water supply systems.[3] Domestic water requirements account for the smallest withdrawal of the three, about 700,000 gallons per day.[4] Under the British Columbia Water Act the priority of these three uses is the reverse of their importance by daily withdrawal. The three primary uses will be discussed according to their rank in this priority; domestic water use followed by waterworks and industrial use.

Domestic Water Use

The Water Act of British Columbia defines domestic water use as "the use of water for household requirements, sanitation, and fire prevention, the watering of domestic animals and poultry, and the irrigation of a garden not exceeding one-quarter of an acre adjoining and occupied with any dwelling-house."[5]

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[2] The value represents the total withdrawal of water for industrial use sanctioned by water licences for the river basin.

[3] This value represents the total withdrawal of water for waterworks use sanctioned by water licences.

[4] This value represents the total withdrawal sanctioned for domestic use by waterworks plus three times this amount which corresponds to the volume used from wells. This calculation is based upon the fact that there are three times as many wells as there are domestic water licences.

[5] British Columbia, Water Act and Regulations, Consolidated July 1, 1965, Victoria, 1966, p. 5049.

In the Cowichan River basin a significant proportion of the residents are not serviced by public water systems but have private supplies drawing on surface or groundwater sources. Wells and springs are the principal source of water for households not on an organized system.[6] From seventy-four responses to a questionnaire survey[7] undertaken in the coastal plain region, fifty-five households reported wells and springs as a source of water supply, nine reported lakes, nine reported streams, eight were on some sort of organized water supply, and three gave no answer. Some households rely on more than one source of water, using for example, a well to supply the house, and a surface source to water stock and the garden.

In the previous chapter, the distribution of wells and aquifer data were discussed. There is much more, however, that may be noted on the use of groundwater for domestic purposes.

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[6] Pers. Comm., Reeve D.C. Morton, District Municipality of North Cowichan.

[7] A questionnaire survey was undertaken for every third house along the principal roads in the coastal plain (Appendix III). Out of 112 questionnaires distributed, 74 were collected by personal calls. The survey was not designed for statistical study but to gauge local opinion on questions of water supply problems and to obtain information on local practices not available from any other source.

In the Cowichan River basin, hand dug wells were the only type in use for many years. In some areas wells as shallow as six to ten feet provided adequate water for domestic purposes. As population density increased, a greater number of homes were situated in areas where groundwater was less accessible so that deeper wells were necessary to tap the aquifer. In some cases these deeper wells were hand dug. Increasingly however, the deeper wells were drilled. The post-war prosperity of the Cowichan area has brought the cost of drilling within the reach of the homeowner, so that many homes, particularly in areas where groundwater exploitation is more difficult, now have drilled wells. Local companies have commenced operations in the Cowichan area making drilling more competitive and thus more economical.

Table II lists the number and average depth of wells and the number of springs by district (Fig. 18) according to the British Columbia Water Investigations Branch Well Inventory. The highest proportion of hand dug wells and the shallowest wells are in Sahtlam district, in the concentration along the road between Paldi and Wheatley. These wells tap a shallow sand and gravel aquifer in the river valley. Somenos District follows in the proportion of shallow hand dug wells. Surface materials are thin in this area, and water is drawn from sand

TABLE II

NUMBER AND AVERAGE DEPTH OF WELLS IN THE COWICHAN RIVER BASIN[8]

District	Total	Hand Dug No.	Hand Dug Average Depth	Drilled No.	Drilled Average Depth	Springs
Comiaken	59	24	20	31	98	4
Cowichan	80	11	24	63	132	6
Cowichan Lake	29	16	20	5	41	8
Quamichan	86	37	22	49	108	-
Sahtlam	42	33	14	7	78	2
Shawnigan	72	29	25	43	104	-
Somenos	167	106	20	61	106	-

and gravel deposits or from fractures in the surface of the bedrock. This is an older centre of development so that wells were dug before drilling became a widespread practice. In Cowichan Lake also, over half the wells are hand dug. Here they tend to be shallow, tapping riparian sources.

In the other districts more than half the wells are drilled. Cowichan District has the highest proportion. These were also the deepest wells in the basin. This district includes the area inland from Cowichan Bay, north and south

[8] British Columbia Department of Lands, Forests and Water Resources, Water Investigation Branch, Groundwater Division, Well Inventory.

of the river in which development of groundwater supplies has been difficult. Deep drilled wells have, in many instances, been the only source of adequate water supply available to the householder. Quamichan, Comiaken, and Shawnigan Districts flank Cowichan District and have similarly high proportions of drilled wells. Conditions of groundwater scarcity are not so severe in these districts as in Cowichan District but development of groundwater has frequently had to be by deep drilled wells.

Wells are a satisfactory water source for many households in the Cowichan basin. Where the yield is tested and found to be adequate the wells will generally continue to maintain that yield over an extended period of use. Cases of reported change in the capacity of a well can usually be attributed to silting or to increased demands upon the well rather than to a decline in the well's capacity.[9]

The yield of many wells fluctuates with the seasons. During the summer when precipitation values are lowest and there is little or no groundwater recharge and demands are highest, the water level of wells may drop considerably. Many households must conserve their water during the late summer

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[9]Hugh Nasmith, Groundwater for Farm Use in Lower Cowichan Valley, Vancouver Island, British Columbia Department of Mines, Groundwater Paper No. 4, Victoria, 1955, p. 5.

and early fall to ensure adequate amounts for daily use. In some cases wells go completely dry during the summer. These households are then forced to use a neighbour's supply or to buy water. One man near Duncan who has a high yield well sells water in thousand gallon plastic bags to replenish dried up wells. The autumn rains of October and November usually recharge groundwater and the levels return to a point where the wells can be freely used once again. Water balance calculations indicate a sufficient surplus during the winter months to service most needs. Local conditions, however, may hinder its exploitation.

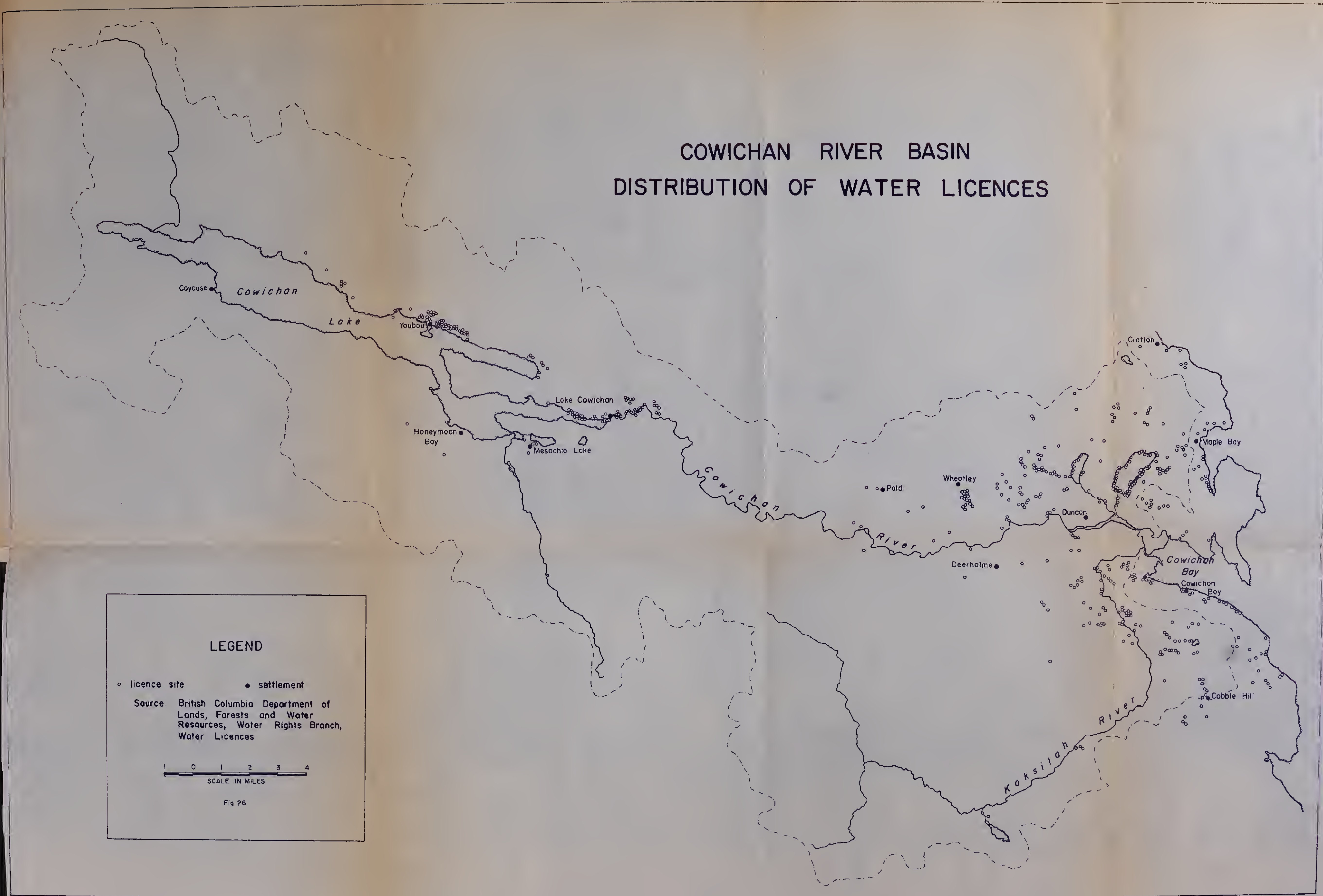
Although in most cases the quality of the groundwater is satisfactory there are aquifers in which concentrations of minerals make the water either unpleasant or impossible to use. Some households north of the Cowichan River report the presence of sulphur or iron in sufficient concentrations to make the water less desirable than they might wish. A few households west of Somenos Lake have such concentrations of sulphur in their water supply that it is impossible to use it for cooking or drinking. Such occurrences are rare, although of great importance to the individual household.

Not all the domestic users in the Cowichan River basin depend upon groundwater supplies. Surface water sources are also important. In British Columbia any use of surface water

must be sanctioned by a water licence detailing point of withdrawal, amount authorized for withdrawal, and the purpose of withdrawal. These licences are indispensible in determining the distribution, volume, and nature of water use in the basin.

Water licences are fairly evenly distributed along the water courses tributary to the Cowichan River in the coastal plain region (Fig. 26). The population of the basin is greatest in this region and people use surface water supplies wherever they are available. No domestic licences are located on the lower reaches of the Cowichan River itself. The river is bordered in its lower reaches by Indian reserves and the expense of piping water from the river to homes beyond the reserves is uneconomic when compared to alternate sources of water. On the Indian lands, use of untreated water is discouraged because of discharge of effluent from the sewage works of Duncan and the District Municipality of North Cowichan.

Along the middle reaches of the Cowichan River there are only a few domestic licences. Population density is low in this region and most of the homes are remote and much above the river. Domestic licences along Lake Cowichan are clustered around the outskirts of the Village of Lake Cowichan and Youbou. These are the largest centres of population in the



COWICHAN RIVER BASIN
DISTRIBUTION OF WATER LICENCES
Caycuse
Cowichan
Lake
Youbou
Lake Cowichan
Honeymoon Bay
Mesachie Lake
Cowichan River
Poldi
Wheatley
Duncan
Deerholme
Crofton
Maple Bay
Cowichan Bay
Cowichan Bay
Cobble Hill
Koksilah River
LEGEND
licence site
settlement
Source. British Columbia Department of Lands, Forests and Water Resources, Water Rights Branch, Water Licences
1 0 1 2 3 4
SCALE IN MILES
Fig 26

lake area and public services do not extend to households beyond their boundaries.

Table III lists the volume of water licensed for domestic use according to the major drainage basins within the Cowichan watershed. The Cowichan itself has the greatest number of licences, followed by Quamichan Lake and the Koksilah

TABLE III

WATER LICENCES ISSUED FOR DOMESTIC USE IN THE COWICHAN RIVER BASIN[10]

Drainage	Final Licenses[11] No.	Final Licenses Withdrawal	Conditional Licenses No.	Conditional Licenses Withdrawal	Total No.	Total Withdrawal
Averill Creek	17	10,000 gpd	6	5,500 gpd	23	15,500 gpd
Bings Creek	8	4,500 gpd	4	2,500 gpd	12	8,000 gpd
Coonskin Creek	23	16,000 gpd	3	1,500 gpd	26	17,500 gpd
Cowichan River	48	38,150 gpd	43	27,133 gpd	91	65,283 gpd
Daly Creek	5	3,000 gpd	0	----	5	3,000 gpd
Koksilah River	23	30,500 gpd	17	29,000 gpd	40	59,500 gpd
Quamichan Lake	35	27,500 gpd	17	16,840 gpd	52	44,340 gpd
Somenos Lake	5	4,500 gpd	7	7,000 gpd	12	11,500 gpd
Utility Creek	11	5,500 gpd	5	2,500 gpd	15	8,000 gpd

[10] British Columbia Department of Lands, Forests and Water Resources, Water Rights Branch, Water Licences, 1966.

[11] According to the British Columbia Water Act a conditional licence is one which authorizes the construction of works or the diversion and use of water prior to the issue of a final licence. A final licence authorizes the diversion of water but not the construction of additional works or any extension of the use of water.

River. The average volume of withdrawal sanctioned for each licence is larger for the Koksilah than for any of the other rivers or lakes within the basin. This reflects the greater number of domestic licences on farms where stock watering is an important aspect of water use. Elsewhere in the basin, licences tend to be for domestic use by rural non-farm households.

The statistics on the volume of water licensed are not completely reliable. Some of the licences may have gone out of use but because the annual rents are still being paid and there is no pressure on the water supply in that area, they are not cancelled. It is possible that in time such licences may be brought back into use by the holder.

Another source of error in the recorded volume of water use is the method of computing the volume of water to be sanctioned by a licence. A conditional licence is issued for a standard amount of water depending upon the requirements of the user. When a final licence is issued the amount authorized for withdrawal is brought into line with the approximate volume being used under the conditional licence. Should the requirements of the licencee change over time, actual withdrawal may be quite different from the terms of the licence.

Not all surface water users possess water licences.

It is not an offence for a person to divert unrecorded water, that is water not covered under an existing licence, but in the event of prosecution under the Water Act it is incumbent upon the person diverting the water to prove that the water is unrecorded.[12] People may through ignorance or intent neglect to obtain a license. The number of such consumers is unknown but several water supply systems operating outside a water licence in the Cowichan basin were alluded to during interviews. It also happens that people building a second house on their property expand the existing water supply system without fulfilling the requirement of getting a second licence.

The system of licensing surface water use has the advantage of safe-guarding the licencee with respect to an adequate water supply over the year. Seasonal and annual fluctuations in streamflow are taken into account in allocating water use. In issuing licences the capacity of the stream at its lowest flow is considered. When the number of licences plus a value calculated to maintain some flow in the stream at all times, approaches the level of low flow for a stream, the issuing of water licences is stopped for that stream.

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[12] British Columbia, op. cit., p. 5065.

Licensing has been so stopped for Daly Creek in the Cowichan basin. This protects the six existing licencees and ensures a continual flow in the stream except perhaps, in times of unprecedented drought. Before a stream becomes fully recorded, that is when licensing is curtailed, a provision may be invoked limiting the use of the stream to domestic users only. Averill Creek, Quamichan Lake and Quamichan Creek have been so limited. Thus the volume of flow for existing licences is assured and the rights of future domestic users are given priority over other types of use.

Surface water quality appears to be good. There are only two chemical analyses available from the Department of Health for surface water in the basin, one for the Cowichan River at Duncan and the other for Quamichan Lake. Both these analyses indicate a favourable quality for domestic use. There is no industry within the basin except the pulp mill at Crofton which could contribute deleterious substances to the water supply. The mill pipes its effluent directly into the sea so that it is not a threat to surface supplies. Sewage treatment within the basin is primarily by individual septic tanks. As there are no regulations in effect in the area as to size of lot for septic tanks it is possible that pollution from a high density of septic tanks could find its way into

surface water bodies. There is no indication of such pollution in the basin at present but it is a possibility as long as there are no regulations. Sewage treatment is provided by Duncan, the District Municipality of North Cowichan, and the Village of Lake Cowichan. On the Indian reserves privys are still in use.

Duncan has a sewage system employing a settling tank and a sewage lagoon which has a capacity for servicing 8,000 people. The effluent from the lagoon is discharged into the Cowichan River. This discharge is no threat to water quality as it is almost completely purified in passing through the system. Similarly effluent into Somenos Creek from the aeration plant used by the District Municipality to service the built up area adjacent to Duncan does not affect water quality. The additional nitrogen in the stream, however, stimulates plant growth so that vegetation is choking the creek. In the Village of Lake Cowichan sewers service the southern part of the town. The sewage is chlorinated and discharged into Cowichan Lake. Both the District Municipality of North Cowichan and the Village of Lake Cowichan hope to expand the area serviced by sewers; the one to the subdivision west of Somenos Lake and the other to the rest of the town.

In the Cowichan River basin not all of the domestic

water users are satisfied with their water supply. Householders are, in some instances, faced with an inadequate quantity of water for their needs or with water of inferior quality. Agitation for the extension of an organized water supply has been most pronounced along the coastal plain north of the Cowichan River where the greatest number of domestic users are located. Here the District Municipality of North Cowichan provides an administrative unit for the installation and maintenance of a public water supply. Referenda have been held to gauge popular support for several schemes but each time they have been defeated. The need for an improved domestic water supply does exist for some users, but this need is not great enough that the majority are willing to support the costs of installation. As population density increases so that costs can be spread among a greater number of residents and the problem affects more of them, the appeal of these schemes will increase.

The plight of those water users with problems of domestic supply, while of concern, affects a minority, and will probably be solved within the next ten or fifteen years. The Cowichan valley is enjoying a period of growth and prosperity. The forest products industry provides a focus around which an increasing number of services are clustering. An expanding

population over the next few years should, through pressure upon local and provincial governments, bring about the means of solving the existing water supply problems. In the event that the present prosperity does not continue, the domestic water user now faced with inadequate supplies should find help from the provincial government. The domestic water user enjoys a priority under the Water Act which ensures that research and planning will be undertaken in water-short areas.

Waterworks

Waterworks, according to the British Columbia Water Act, is the "carriage or supply of water by a municipality, improvement district, development district, or a person for the use of the residents of any locality."[13] In the Cowichan River basin municipal water services are furnished by the city of Duncan, the Village of Lake Cowichan, and the District Municipality of North Cowichan. Company-owned systems provide water to the sawmill communities of Honeymoon Bay, Mesachie Lake, and Youbou, and to the lumber camp at Caycuse. The smaller communities of Cowichan Bay and Eagle Heights have been organized as waterworks districts for the purpose of

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[13] Ibid., p. 5052.

water supply. Individuals supply water to residents east of Youbou, and at Cobble Hill.

The water supply for the city of Duncan was, for some time, obtained by gravity flow from Bings Creek in the winter, and by pumping from the Cowichan River in summer. Bings Creek was the more easily utilized source of water but it lacked adequate volume during the summer months, so that pumping from the Cowichan River was necessary. A reservoir with a capacity for 1,500,000 gallons provided storage. The water was chlorinated.

More recently, wells along the river tapping riparian flow have replaced surface water sources at Duncan. Two wells presently supply the town. The major one, which does not require chlorination, yields 1,000 gallons per minute (gpm). The second well, formerly the main source and now a supplementary one, has a flow of 1,200 gpm. This water must be chlorinated.

The city retains three licences for the Cowichan River of 270,000 gpd., 19,800 gpd., and 1,000,000 gpd. respectively. These licences are for emergency use and ensure adequate future supplies.

There are no metres in the Duncan system so water use is only approximately known. Table IV lists the estimated water

TABLE IV

MUNICIPAL WATER USE, CITY OF DUNCAN, 1960 TO 1966[14]

	Jan.1-Dec.31 1960	Jan.1-Dec.31 1961	Oct. 1, 1961 to Sept.30, 1962	Oct. 1, 1962 to Sept.30, 1963	Oct. 1, 1963 to Sept.30, 1964	Oct. 1, 1964 to Sept.30, 1965	Oct. 1, 1965 to Sept.30, 1966
Annual Water Consumption in Gallons	253,280,500	287,938,900	255,855,000	276,988,500	315,410,500	330,941,700	370,001,800
Average Daily Consumption in Gallons	666,500	788,868	---	---	864,138	905,867	1,013,704
Maximum Daily Demand in Gallons	1,741,857	1,797,271	2,044,489	1,800,000	1,963,000	2,568,000	2,401,000
Minimum Daily Demand in Gallons	371,928	205,857	544,457	600,000	531,000	531,000	528,000
Number of Residential Connections	1275	1095	1130	1649	1662	1689	1791

[14] British Columbia Department of Lands, Forests and Water Resources, Water Rights Branch and City of Duncan, City Clerk.

consumption and the number of residential connections since 1960. In the summer of 1966 the city was supplying water to 1,791 households or approximately 7,000 people. Of these, 1,077 families were in Duncan and 714 were in the District Municipality of North Cowichan adjacent to the northern boundary of Duncan.

The Village of Lake Cowichan, for many years, obtained its water under a licence for 200,000 gpd. from Stanley Creek. When logging operations in the Stanley Creek area threatened to alter water quality and stream regime, a new system was designed. The present water supply system pumps water from Lake Cowichan into a 500,000 gallon storage tank. The water is chlorinated and fluoridated. Two licences authorize a total withdrawal of 600,000 gpd. from the lake. Table V lists the estimated water consumption and the population served by the Village of Lake Cowichan since 1960. In the summer of 1966 the system supplied 613 residential connections or approximately 2,000 people. The average daily metered consumption at that time was 625,000 gpd.[15]

Water servicing in the District Municipality of North Cowichan is not continuous. Within the Cowichan basin only

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[15] Pers. Comm. Mr. Chappell, Municipal Clerk, Village of Lake Cowichan.

TABLE V

MUNICIPAL WATER USE, VILLAGE OF LAKE COWICHAN, 1961 TO 1966[16]

	1961	1962	1963	1964	1965	1966[17]
Water Consumption in Gallons	--	--	--	--	--	--
Average Daily Consumption in Gallons	394,900	398,900	418,400	425,400	466,200	492,400
Maximum Daily Demand	513,700	518,200	530,600	550,800	614,000	646,100
Minimum Daily Demand	276,200	279,700	286,200	300,100	318,500	343,200
Number of Residential Connections	576	589	597	602	612	623
Estimated Population	2250	2300	2320	2350	2375	2450

[16] Village of Lake Cowichan, Municipal Clerk.

[17] Figures given for 1966 are for the ten-month period January 1st to October 31st.

the south end of the municipality adjacent to Duncan, the subdivision west of Somenos Lake, and the communities of Maple Bay and Crofton have a public water supply. The remaining households in the municipality have private systems based upon surface or groundwater sources. Table VI lists the number of connections in the municipal systems at Somenos, Maple Bay, and Crofton since 1960. Figures for the part of the municipality serviced by the Duncan system are included in Table IV.

A subdivision of about thirty houses west of Somenos Lake is serviced by water pumped from the lake and stored in a 10,000 gallon tank. The volume licensed for withdrawal under this system is 50,000 gpd. The water supply for the subdivision is not completely satisfactory as the water from Somenos Lake has a brackish taste and contains organic materials.

The community of Maple Bay holds two water licences authorizing the withdrawal of 125,000 gpd. from Quamichan Lake. This is pumped into a 12,000 gallong storage tank and distributed by gravity flow. The water supply is adequate although the distribution system is not. Sprinkling regulations have been instituted to guard against the possibility of the lines being drained in the event of fire. Expansion of the Maple Bay system to supply the built up area to the south

TABLE VI

NUMBER OF CONNECTIONS TO THE WATERWORKS OF THE DISTRICT MUNICIPALITY OF NORTH COWICHAN AT CROFTON, MAPLE BAY AND SOMENOS[18]

	Oct. 1960	Sept. 1961	Sept. 1962	Sept. 1963	Sept. 1964	Sept. 1965	Sept. 1966
Crofton	165	173	180	169	173	No data	No data
Maple Bay	129	130	135	130	132	"	"
Somenos	31	31	32	27	32	"	"

[18] British Columbia Department of Lands, Forests and Water Resources Water Rights Branch.

of the presently serviced area is currently being investigated.

Water is supplied to the community of Crofton by gravity flow from Crofton Lake. The water licence held for waterworks purposes on the lake is for 20,000 gpd. Crofton has a 30,000 gallon storage tank operating by gravity flow with a booster pump to service one of the subdivisions.

The remaining developed area of the District Municipality of North Cowichan has a water problem because of the economic difficulty of supplying water to a low density population. Water is available for waterworks purposes but the people are unwilling to sanction its development while there is the possibility of high cost to the individual householder. Thus many remain dependent on groundwater supplies which are of inferior quality or insufficient quantity. When the demand for a public water supply increases to the point where the residents are willing to commit themselves to a plan requiring monthly payments for water, a system will be developed. One proposed bylaw was recently defeated which was designed to supply water to an area within the municipality at a cost not in excess of $9.00 per month.[19] The residents may have water supply problems but these are not sufficiently pressing that

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[19] Pers. Comm., Reeve Morton, District Municipality of North Cowichan.

they will undertake the financing of a public water supply scheme.

The water supply for Honeymoon Bay comes from MacPherson Creek. A dam has been constructed about a mile upstream from the townsite to impound water in a small basin. The system operates by gravity flow. The volume of water licensed for use by Honeymoon Bay is 50,000 gpd. of which about 25,000 gpd. is presently adequate, to service the 126 houses. Cowichan Lake is used as an alternate source of water in an emergency.

Mesachie Lake was originally supplied with water from wells. The water developed a discolouration and the insides of the pipes became clogged with a slime which occasionally discharged in the tap water. After some investigation the source of supply was changed to Bear Lake, a bay of Lake Cowichan. The company holds a licence for withdrawal of 100,000 gpd. from the lake for waterworks purposes. Water is pumped from Bear Lake into a storage pond with a capacity of 70,000 gallons and distributed to forty-five houses by gravity flow. The water is chlorinated and flouridated.

Water is supplied to sixty houses at Youbou under a licence for the withdrawal of 12,000 gpd. from Youbou Creek. Additional water for garden use is obtained from Lake Cowichan.

The main source of water at Caycuse is Regan Creek from

which 15,000 gpd. may be withdrawn under licence. A well near the lake is used for fire protection and to supplement domestic supplies in times of low summer flow. Water is stored in a 50,000 gallon tank and distributed to 100 houses.

Normally waterworks systems are associated with municipal government or company administration. Under the Water Act, however, provision is made for unincorporated communities to set up an organization for the purpose of supplying water to the residents. Any group of six or more licencees may be incorporated into a water-users' community by the Comptroller of Water Rights for British Columbia.[20] A water-users' community is a public corporate body with a manager and committee directed by the members of the community. Periodic meetings of the community are held to determine policy and elect officers. Once a community is formed, it has the same responsibilities and rights with respect to supplying water and assessing for its supply as a municipality.

There are two water-users' communities in the Cowichan River basin, the Cowichan Bay Waterworks District and the Eagle Heights Waterworks District (Fig. 27). Cowichan Bay used to get its water from a spring near the waterfront.

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[20] British Columbia, op. cit., p. 5084.

WATERWORKS DISTRICTS OF COWICHAN BAY AND EAGLE HEIGHTS

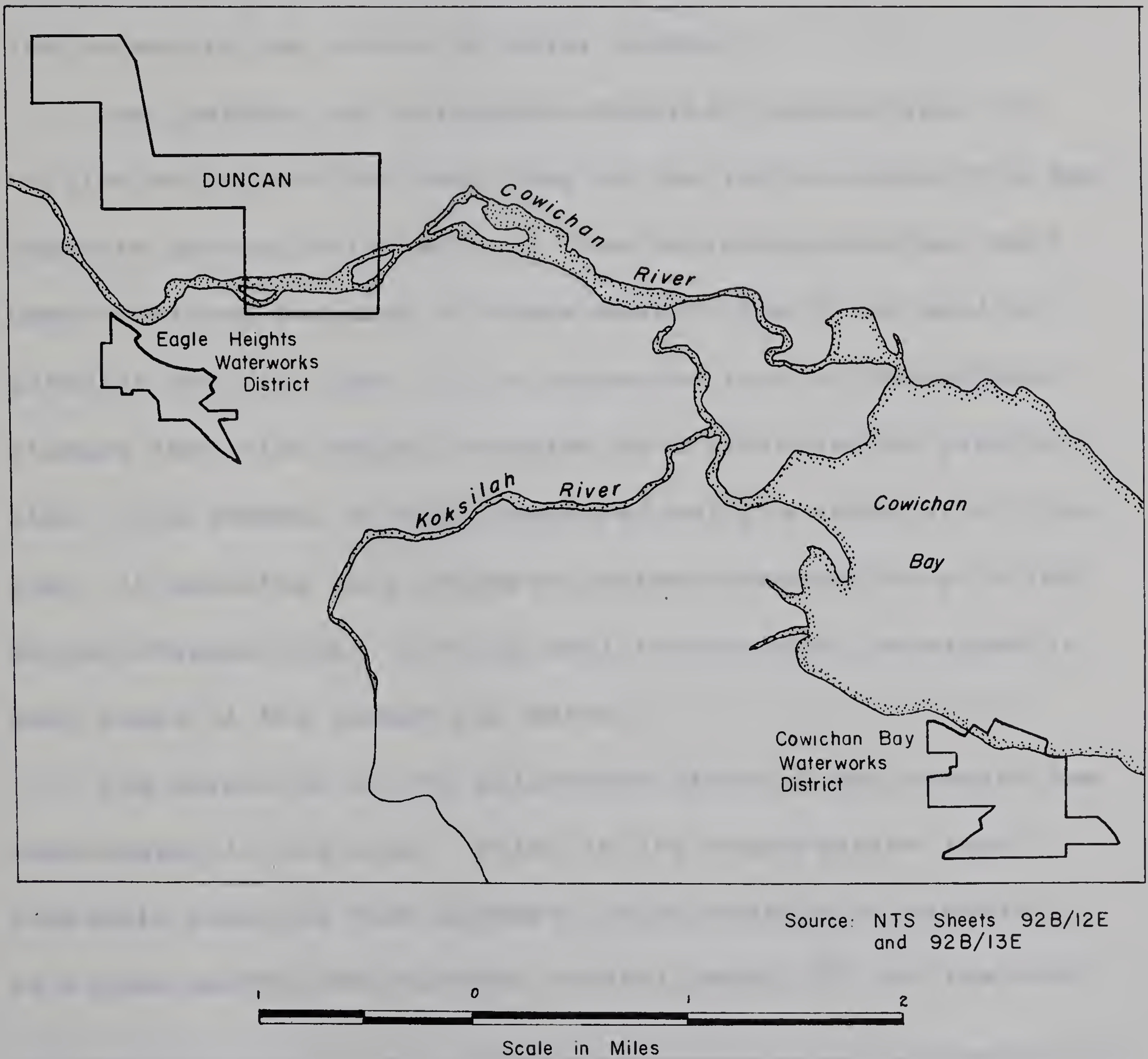

Fig. 27

Water was piped north and south along the shore to serve the existing houses. The quantity of water was not adequate for the system because, when water was being taken for use at one end of the pipe, pressure dropped at the opposite end. The pipe eventually broke and the water carried by it became contaminated. A water-users' community was formed to develop the necessary new source of water supply.

The Cowichan Bay Waterworks District depends upon two drilled wells over 200 feet deep on the terrace above the sea. Separate systems which will in time be interconnected, have been developed for each of these wells. The first well is rated at 200 U.S. gpm. It is connected to a 30,000 gallon storage tank from which the water is distributed by gravity flow. The second, a newly developed well, is rated at 60 U.S. gpm. It operates on a pressure system connected to a 10,000 gallon storage tank. A third well is now being developed to keep ahead of the demand for water.

The formation of the waterworks district has brought new development to the area. Prior to its organization local residents reported that property sales were at a standstill, as no one wanted land without a water supply,[21] and the land

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[21] Mrs. D. Lawrence of Cowichan Bay, letter July 6, 1954--British Columbia Water Investigations Branch, File No. 0157643.

above the sea front yielded little water to shallow, hand dug wells. Since the water supply has been assured, subdivision of the land has taken place. Now, farmers with land adjacent to Cowichan Bay are holding their property in expectation of further subdivision. The water system is set up to expand with the growth of the community. Each new developer is required to provide a source of water and $200.00 per lot to cover the expenses of extending the existing system.[22]

The residents of Eagle Heights, prior to the organization of the water-users' community, obtained their water from individual shallow wells. There was an adequate supply available for domestic use but the fine sand aquifer necessitated frequent desilting of the deeper wells and the forced abandonment of several. The local people felt that a communal system would circumvent the difficulty of maintaining individual wells under such conditions. The Eagle Heights Waterworks District was duly formed. The members are serviced from a well located in the flood plain of the Cowichan River which taps riparian flow.

There are two waterworks systems outside any of the aforementioned administrative units. Some of the houses at

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[22] Pers. Comm., George Highmoor, Chairman, Cowichan Bay Waterworks District, Cowichan Bay.

Youbou and at Cobble Hill are supplied by privately owned waterworks systems. At Youbou, the houses east of the company-serviced section of the community buy water from two individuals who hold licences for waterworks purposes. One of these licences authorizes the withdrawal of 25,000 gpd. from Coonskin Creek, and the other the same amount from Utility Creek. At Cobble Hill, under a similar arrangement, one man supplies water from a licence on Constance Springs for 30,000 gpd.

The future outlook for availability of water for waterworks purposes in the Cowichan River basin is favourable. The municipal supplies of Duncan and the Village of Lake Cowichan are located on the Cowichan River and on Lake Cowichan respectively. These sources are abundant and of good quality, so there appears to be assurance of ample water supply for the foreseeable future. Both municipalities have attempted to ensure adequate future supplies by retaining old licences as new systems are introduced.

The District Municipality of North Cowichan is not yet fully serviced. Water shortages in the late summer and early fall, and problems with unfavourable water quality, affect some of the residents of the municipality on private systems. Others, also on private systems, have ample water. The policy

of the municipality is to provide services for the expanding population. As the density of housing becomes sufficient to sustain the cost of installation of water facilities, these will be provided. Studies have been made as to possible sources of the necessary water. The Cowichan River is an obvious source and diversion would be possible to supply the needs of the District Municipality. The Chemainus River to the north of the Cowichan River basin is a potential alternate source.[23] The boundaries of the District Municipality extend into the Chemainus watershed and diversion would be feasible to service part or all of the District Municipality in the Cowichan basin.

The Waterworks Districts of Cowichan Bay and Eagle Heights have comparatively small areas to be serviced. Problems attendant upon a rapid increase of houses in these areas could develop, but this is not likely in view of the policy of the one district and the site of the other. Cowichan Bay is in an area which is short of surface water. Deep wells, however, can supply the needs of the community and have permitted new housing developments. The policy of the Cowichan

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[23] British Columbia Department of Lands and Forests, Water Rights Branch, Reconnaissance Survey of Irrigation and Domestic Water Supply Possibilities For the Duncan Area, by T.A.J. Leach, Victoria, 1952, p. 9.

Bay Waterworks District requiring new subdivisions to provide their own source of water and a cash deposit for each new lot brought into the Waterworks District should serve to hold back building until an adequate water supply is assured. The Eagle Heights Waterworks District, on the other hand, does not have a problem with water supply but with the silting of individual wells. Should the demand for water increase in Eagle Heights, additional wells alongside the Cowichan River or diversion of the river itself, could expand the present system.

Industrial Water Use

In the British Columbia Water Act, industrial use is interpreted as "the use of water for any purpose other than the purposes elsewhere defined"[24] in the Act. Generally, however, it refers to water used in manufacturing.

The most important industrial activity in the Cowichan River basin is the processing of forest products. A few companies produce such commodities as crushed rock and cement blocks, but their operations are on a small scale and the volume of water required is insignificant when compared with

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[24] British Columbia, op. cit., p. 5050.

the forest products industries. The major industrial water use then, is associated with large enterprises operating on independent supplies and possibly servicing an adjacent company town. The various waterworks systems, with the exception of the Village of Lake Cowichan, have no industrial use made of their water. The Village of Lake Cowichan provides water for fire protection to two sawmills.

There are three sawmills on Cowichan Lake with independent water supplies, at Honeymoon Bay, Mesachie Lake, and Youbou. A kraft pulp mill at Crofton in the lower part of the basin is the fourth major user of industrial water.

The mill at Honeymoon Bay, owned by Western Forest Industries Limited, produces shingles, lumber, and pulp chips. The annual output is 9 million board feet of lumber from a mill employing 500 men. The water supply for the mill comes from MacPherson Creek under a water licence authorizing the withdrawal of 500,000 gpd. Most of this water is used for the production of power. Other uses of water in the mill are for fire protection and cooling. Very little water is used in processing the logs.

The mill at Mesachie Lake, operated by Hillcrest Lumber Company, produces lumber and pulp chips. The mill employs 300 men to produce about 40,000,000 board feet annually. The

company holds two water licences for industrial use, one for withdrawal of 400,000 gpd. from Bear Lake, and one for 3,000,000 gpd. from Mesachie Lake. The softer water from Mesachie Lake is used for boiler feed. The water from Bear Lake is used for such purposes as fire protection and washing.

The mill at Youbou, owned by British Columbia Forest Products Company Limited, produces lumber, pulp chips, and green veneer. The output of the mill is 600,00 board feet per day. The company has two licences on Lake Cowichan to supply water to the mill. One licence authorizes the withdrawal of 2,000,000 gpd. and the other the use of 32 cfs. The water is used for power generation, log barking, cooling, and fire protection. The boiler capacity is 100,000 gpd. An approximately equal amount is used for other purposes in the mill. A storage tank with gravity flow is kept filled for fire protection.

The Crofton mill processes the pulp chips from Youbou and elsewhere into newsprint and kraft pulp. The plant employs 850 men to produce 950 tons of market kraft and 375 tons of newsprint per day. Water for the mill is obtained by diversion from the Cowichan River (Fig. 28). A weir at the mouth of Lake Cowichan was constructed by the company to store flood waters in the lake so that water would be available for

MAP OF CROFTON DIVERSION

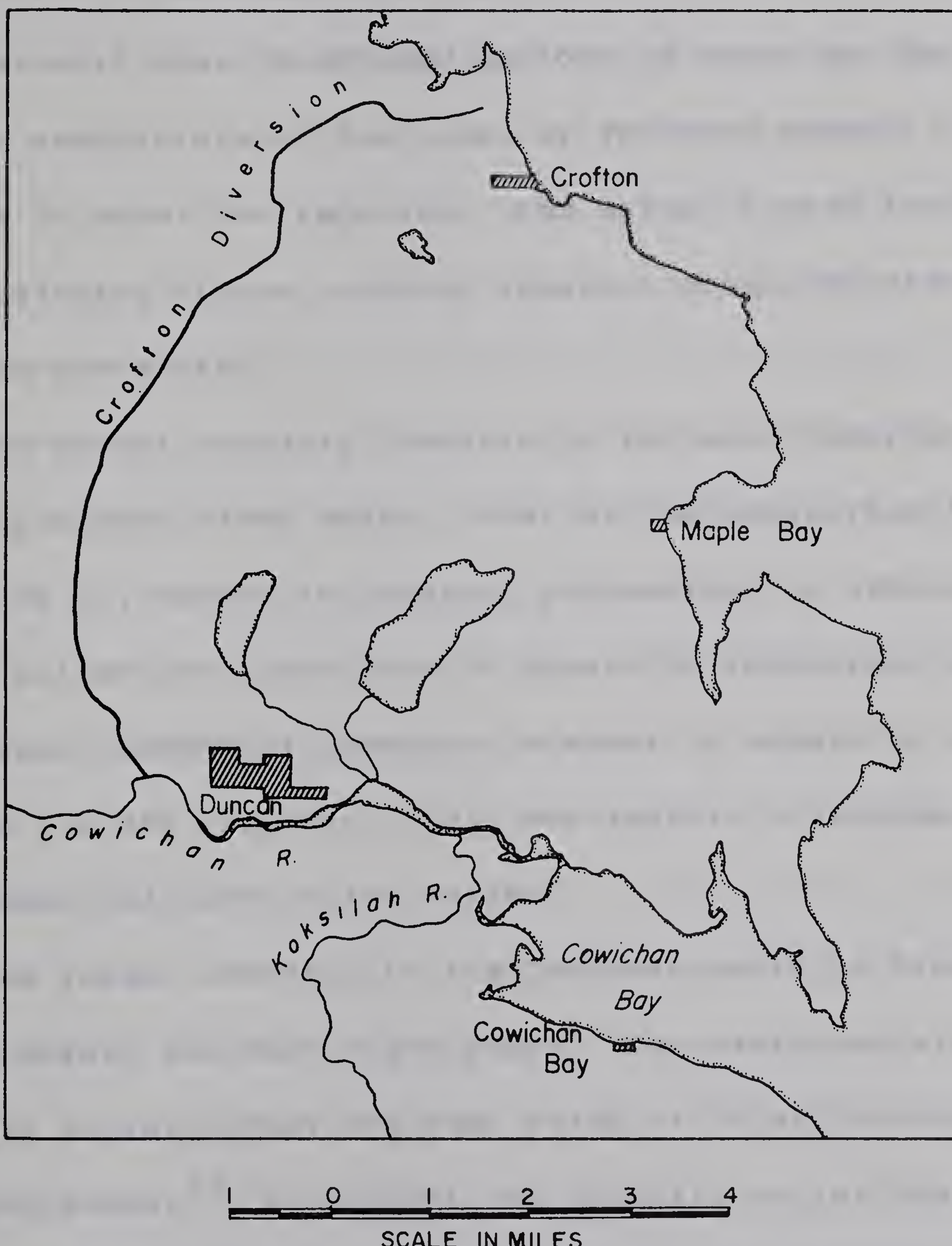

Fig. 28

diversion downstream during periods of low summer flow. A water licence authorizes the storage of water in Lake Cowichan and the diversion of 250 cfs. from the river, provided a flow of 100 cfs. is maintained in the river.

The mill uses 50,000,000 gallons of water per day. Thus, for the manufacture of one pound of finished product, 192 gallons of water are required. The water is used for dilution, carrying fibres, cooling liquors, producing steam, and for fire protection.

The forest products industry is the most important one in the Cowichan River basin. Most of the population is sustained by it, either in logging, processing, or servicing. Little attempt has been made to diversify industrial activity. The Duncan Chamber of Commerce is about to embark on a survey of need for new industry. This may lead to a broadening of the industrial base of the valley.

The forest industry in the Cowichan basin is faced with change within the next fifty years. The sustained yield capacity of the forest has been rated at 50 million board feet per annum.[25] At present the sawmills on the lake are using four times that amount of timber. As a result of high

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[25] British Columbia Forest Service, The Cowichan Lake Forest Experiment Station, Victoria, 1952, p. 8.

rates of cutting since the 1930s, a large proportion of the forest is thirty years old or less. These trees will not be ready for cutting under the present system of utilization for another forty or fifty years.[26] The combination of these factors will force the existing companies either to reduce their present level of activity or to reorient their emphasis. Should the companies contract their activities, a lower level of industrial water consumption will prevail. Should they, as is more likely, make adjustments in their present operations, there will be a gradual trend toward the utilization of smaller trees and the more complete utilization of each tree. As this happens, chemical processing will replace the mechanical processing of the sawmill. Manifestations of this are already evident in the construction of the kraft pulp mill at Crofton to utilize pulp chips from the sawmill at Youbou. This transition may increase the demand for industrial water in the Cowichan basin, as chemical plants require water for a greater variety of processes than do sawmills. The transition may also increase industrial pollution which is presently at a low level, as the effluent from Crofton, the most important potential source of pollution, is discharged

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[26] Pers. Comm., R.H. Spilsbury, B.C. Forest Service, Victoria.

directly into the sea without entering the drainage system of the Cowichan River.

In order to prevent industrial pollution of the Cowichan watershed and to preserve the quality of the recreation resource, another important source of income to the area, regulations for the disposal of effluent from chemical plants which might in future be situated in the Cowichan basin should be established prior to their development. The forest products industry already has a large investment in the area in forested land, research projects, and facilities. Should they continue to diversify their production, as they have done in the last few years, the financial ties they have in the area will outweigh the deterrent effect of regulations on the disposal of effluent in site choice. Once industrial pollution has been introduced into a river system by one plant, it is then difficult to force new plants to adhere to a standard of clean water. From the viewpoint of water quality, it is better to hold back growth for a few years but ensure the maintenance of water quality than to allow a measure of pollution in the hopes of expanding the economy.

A secondary base for economic activity in the Cowichan basin and a much less significant one, is agriculture. Use of water for irrigation will be treated separately. Mention

at this time will be made only of agricultural processing, an activity which has declined in recent years in the valley. The Cowichan Creamery Association was established in the late 1880s to convert cream to butter for the Victoria market. Their activities expanded to handling eggs, milling feed, and processing milk. Of late the name of the Association has been changed to the Cowichan Cooperative Services. Their present activities are confined to milling feed. Milk is now processed in Victoria and the farmers handle their own eggs. With a good highway linking the Cowichan valley to Victoria and the declining importance of agriculture in the basin, it is unlikely that agricultural processing will develop as an important consumer of water.

CHAPTER V

WATER UTILIZATION: SECONDARY USES

Domestic, waterworks and industrial purposes account for the greatest withdrawal of water from the Cowichan system. Other uses, requiring smaller volumes of water or using the water in place, are also part of the pattern of water utilization within the basin. Some uses such as agriculture, mining and power require a comparatively small volume of water. Others, such as fish, wildlife, recreation and navigation, make use of the water in the river system itself and do not remove water from it.

Agriculture

The British Columbia Water Act separates agricultural water withdrawal according to its use for stock watering or irrigation. Under the Act, stock watering is considered a domestic water requirement, so that withdrawal for stock is included in total domestic water withdrawal already considered. Water for irrigation is licensed separately and so is treated in detail in this section.

In the Cowichan River basin, farming is confined to

the coastal plain where there are presently about fifty full time dairy farmers on holdings averaging about eighty acres.[1] There are perhaps twice as many part time farmers on smaller holdings of five to thirty acres.[2] Dairying is the principal enterprise, followed by beef cattle and poultry raising. The raising of beef tends to be an activity of part time farmers as it requires a minimum of labour.

In the Cowichan valley, climatic data and water balance summaries indicate a period of moisture deficiency for agriculture for most of the growing season (See Appendix II). This deficiency can severely limit crop production unless irrigation facilities are installed.[3]

Irrigation is practiced by almost every farmer who has access to water. Over fifty per cent of the dairy farmers are irrigating their pasture although many supplies are insufficient.[4] Of those farmers interviewed in the questionnaire survey, two-third felt that irrigation was necessary and

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[1]Pers. Comm., Mr. Jamieson, District Agriculturist, Duncan.

[2]Out of twenty-eight farmers polled in the questionnaire survey, only one-third were full time farmers.

[3]British Columbia Department of Agriculture, Agricultural Outlook Conference 1966, Report of Proceedings, Victoria, 1966, p. 74.

[4]Pers. Comm., Mr. Jamieson.

would lead to increased yields of two to three times those obtained without irrigation. The major factors limiting expansion of irrigation facilities were, in their opinions, a lack of individual water supplies and the expense of installation.

Both groundwater and surface water sources, and in a few cases, dugouts, are used for irrigation. Surface water, when available to the farmer, is the most easily developed. Table VII lists the number of licences and the amount sanctioned for withdrawal for irrigation from the major basins within the Cowichan watershed. There is a concentration of licences on the coastal plain, particularly on the Koksilah River. There are no licences for irrigation in the upper watershed. Although wells tapping riparian sources and high yield wells have been used in a few instances, the use of groundwater for irrigation has been little explored. The lowering of the water table during the summer drought frequently precludes extensive withdrawals for irrigation. Dugouts are not usually satisfactory sources of water unless they are spring fed. Where they depend upon winter runoff and groundwater recharge, their yield is not usually sufficient.

The irrigation requirement in the Cowichan area is

TABLE VII

WATER LICENCES ISSUED FOR IRRIGATION PURPOSES IN THE COWICHAN RIVER BASIN[5]

	Final Licences			Conditional Licences			Total		
	No.	Withdrawal	Acreage	No.	Withdrawal	Acreage	No.	Withdrawal	Acreage
Averill Creek	4	83.1 ac.ft.	83.1	1	10 ac.ft.	22	5	62.1 ac.ft.	105.1
Bings Creek	2	31 ac.ft.	31	4	50.6 ac.ft.	50.6	6	81.6 ac.ft.	81.6
Coonskin Creek	0	--	--	0	--	--	0	--	--
Cowichan River	6	22 ac.ft.	22	12	558 ac.ft.	558	18	580 ac.ft.	580
Daly Creek	0	--	--	0	--	--	0	--	--
Koksilah River	8	342.2 ac.ft.	294.1	17	867 ac.ft.	767	25	1209.2 ac.ft.	1061.1
Quamichan Lake	4	46.3 ac.ft.	46.3	6	272 ac.ft.	252	10	318.3 ac.ft.	298.3
Somenos Lake	6	29.5 ac.ft.	29.5	11	484.5 ac.ft.	362	17	514.0 ac.ft.	66.5
Utility Creek	0	--	--	0	--	--	0	--	--

[5]British Columbia Department of Lands, Forests and Water Resources, Water Rights Branch, Water Licences, 1966.

from sixteen to twenty-four inches of water per acre of land.[6] Most of the water licences for irrigation allow twelve inches of water per acre for the irrigation season. Only a few permit the withdrawal of eighteen or twenty-four inches. Thus, many farmers who irrigate, do so irregularly. Those with minimal supplies or those using dugouts, apply water in the early spring and again in July, the first application to aid new crops in establishing themselves, and the second to extend the use of pasture later into the summer. Others may irrigate once a month and still others with abundant supplies irrigate some part of their holdings daily.

In 1953, representations from the Cowichan Agricultural Society led to an investigation of the possibility of establishing an improvement district to supply irrigation water to the area. The three rivers of the region, the Cowichan, the Koksilah, and the neighbouring Chemainus were considered to determine their suitability as water sources. The Koksilah was soon eliminated because of its irregular flow and the absence of sufficient potential storage to modify it. The Cowichan, because of the storage available in the lake, was

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[6] British Columbia Department of Land and Forests, Water Rights Branch, Preliminary Survey of Irrigation and Domestic Water Supply Possibilities For the Duncan Area, by G.J.A. Kidd, Victoria, 1953, p. 1.

considered a possible source, with water to be supplied by gravity flow through diversion at Skutz Falls. The storage capacity of the lake has subsequently been utilized to supply the requirements of the pulp mill at Crofton, and it is unlikely, because of the lowlying built-up area at the east end of the lake, that this could be increased. The Chemainus River to the north of the Cowichan basin, appeared the best source of irrigation water because of three potential dam sites and the possibility of obtaining water by gravity flow from two of them.[7]

Little was done in providing for an irrigation scheme aside from drawing up a preliminary report. It was decided that the farms in the basin were too scattered for incorporation into an improvement district for the purpose of supplying irrigation water and that any irrigation scheme would have to be on a much smaller scale.

Without irrigation, agriculture in the basin is not efficient. Natural pastures must be abandoned early in the summer and hay brought in for dairy and beef cattle. This substantially increases farm costs with the result that milk production on Vancouver Island is more expensive than

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[7]British Columbia Department of Lands and Forests, Water Rights Branch, op. cit., pp. 1-8.

elsewhere in British Columbia. Hay is brought into the valley from interior British Columbia and from the State of Washington. With an increase in production expected over the next ten years of twenty-five per cent for milk and fifty per cent for beef,[8] the demand for hay should also increase. Hay scarcity or increased costs of hay could result in a contraction of agricultural endeavours in the basin despite a market which is expected to double by 1985.[9]

Irrigation cannot be claimed as a perfect solution to the agricultural situation in the Cowichan basin. Most of the land being farmed is in pasture or forage crops. Labour costs are high because of competition from the forest products industry. The high cost of water per acre which might be necessary under an extensive irrigation scheme is not, therefore, economically feasible for such low intensity uses. A conversion to high intensity crops such as fruits and vegetables would quickly glut the market and competition from low cost California produce could ruin a new venture.

It would appear that, where the development of irrigation facilities is economically feasible for the individual

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[8]British Columbia Department of Agriculture, op. cit. p. 86.

[9]Ibid., p. 82.

farmer, they have been installed. Most of the other farmers recognize the need for irrigation, and it is likely that were it possible, they would construct systems on their own holdings.

In view of the present limited market for the truck produce of Vancouver Island and the stiff competition from the United States, the present concentration of agriculture in dairying, beef and poultry is inevitable. Currently, the dairy industry is not completely supplying the fluid milk requirements of Vancouver Island, but is being supplemented by competing Lower Fraser valley sources. Without sufficient milk supplies to provide for market needs and a surplus for manufacture into dairy products, the position of the dairy farmer is not stable, subject to the competition of the more economic Fraser valley producer. Present dairy operations in the Cowichan valley are, for the most part efficient, with better than average yields.[10] An ensured local winter feed supply and a longer grazing period on fresh pasture are required to bring down costs and to increase production. Only the introduction of irrigation on a large scale can ensure this change.

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[10]British Columbia Department of Agriculture, Agricultural Development, Vancouver Island, First Approximation Report, Manuscript, Victoria, p. 17.

The continuation of dairying under a locally financed irrigation scheme would, however, not be economic so that government subsidy is necessary. The mainland market is expected to increase in the next few years leaving a smaller surplus from Fraser valley sources for Vancouver Island consumption. Under such circumstances an ensured and economic supply of milk and dairy products from local sources would become a necessity for the island and a government irrigation scheme might become the means of achieving self sufficiency in milk production.

On the other hand, in ten or twenty years, when the area economy is better able to absorb locally grown intensive crops, a large scale, locally developed, irrigation scheme might become practical. By then, intensification of farming and urban expansion into farm land presently being held for subdivision, may localize the agricultural sector of the Cowichan basin so that the area might be more economically serviced by an irrigation scheme. Water for such a scheme might still be available from the Chemainus River. More likely, however, a detailed survey of water utilization patterns at that time would be necessary before determining project feasibility.

A second problem related to water supply facing farmers in the Cowichan basin is that of drainage. Several lowlying

areas and some clay loam soils are unsuited to agriculture, particularly fruit trees, without drainage. The Somenos Drainage District was established to reclaim the lowlying land around the lake and along Richards Creek. A long swamp which is now cropped was ditched for drainage. The District was dissolved in 1960 when as much reclamation as was possible on the low site was completed. Elsewhere farmers have installed their own tile drains or have adjusted their crops to the character of their land.

Mining

The British Columbia Water Act defines the withdrawal of water for mining purposes as "the use of water for recovering mineral from the ground or from ore".[11] At present there are no mines being worked in the Cowichan basin. In the past there were a number of small mines developed in the hills to the north, but these have long been abandoned. From 1957 to 1960 the Cowichan Copper Company Limited operated a mine at Gordon Bay on Cowichan Lake which, before it closed was milling in excess of 400 tons of copper ore per day. The company still retains a water licence for the mine for the

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[11] British Columbia, Water Act and Regulations; Consolidated July 1, 1965, Victoria, 1966, p. 5050.

withdrawal of 300,000 gpd. from the lake and anticipates that the mine may reopen within a few years.[12]

Mining activity introduces the threat of pollution into an area. The sediment or noxious elements in mine tailings can quickly reduce the water quality in a small watershed and can cause local problems in a large one. When the Cowichan Copper Company first began operations in the valley, their activities posed a threat to the scenic beauty of a portion of Cowichan Lake. The copper mine had two tailing ponds for settling out the heavier materials in the water discharged from the mill. In dry weather there was no overflow from these ponds into the lake. In wet weather, however, water from the ponds flowed into an old stream course which emptied into Cowichan Lake at the park reserve on Gordon Bay. The deposit of sediment at the mouth of the stream threatened to alter the character of the beach at the park site.

As a result of negotiations with the company by provincial government departments concerned with maintaining the appearance of the beach and preserving fish populations, the number of tailing ponds was increased to four. All the settling was designed to take place in the first three ponds

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[12] Pers. Comm., Oswood G. MacDonald, President Cowichan Copper Company Limited, Vancouver.

and the water from the fourth pond was pumped back to the mill for reuse. Overflow from the fourth pond occurred only in extremely wet weather. When there was an overabundance of water in the settling ponds, some was diverted without settling into Cowichan Bay at a point west of Gordon Bay. When there was a water shortage, the supply from the fourth pond was augmented by pumping from Cowichan Lake. With these modifications, the conflict between the mine and recreation use at Gordon Bay was resolved.[13]

Mining in the Cowichan basin is not important at present. Mineral deposits of copper, manganese and molybdenite have been located in the area which might, under different conditions of market and labour, be suitable for economic exploitation.[14] Within the recent past a mining endeavour has threatened the water quality and scenic beauty of a portion of Cowichan Lake. Should mining activity develop once again these problems could reassert themselves. The attention of several government agencies to the problems of water pollution is increasing, however, and it seems likely that, should new

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[13] British Columbia Department of Recreation and Conservation, Parks Branch, File No. 111-87.

[14] James T. Fyles, Geology of the Cowichan Lake Area, Vancouver Island, British Columbia, British Columbia Department of Mines, Bulletin No. 37, Victoria, 1955, pp. 17-20.

mining activities threaten water quality, they would have the interest and the administrative means to effect a change in mining operations.

Power

Hydro power was once considered an important potential resource in the Cowichan River basin. Early surveys named the Cowichan River as a source of power because of the storage provided by the lake.[15] In water power surveys published in 1919 and 1924 the developable output of power on the Cowichan seemed promising. Over the years the site of Skutz Falls (Photo 5) was repeatedly considered for development to supply power and light to the city of Duncan. It was proposed to increase the six to ten foot head of the falls to twenty-two feet by constructing a twelve foot dam and rock-cut channel.[16] The project was abandoned as being too costly for the Duncan City Council to undertake, and power continued to be brought from outside the valley.

The Koksilah was never considered as a possible source of power because of its irregular flow and lack of natural

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[15] G.R.G. Conway, Water Powers of Canada, Province of British Columbia, Department of the Interior, Dominion Water Power Branch, Ottawa, 1915, p. 162.

[16] Arthur V. White, Water Powers of British Columbia, Canada Commission of Conservation, Ottawa, 1919, p. 260.

storage.[17] Grant Lake is the only storage site on the Koksilah and, as it is located on a tributary to the main stem, it has little effect in moderating flows.

Now that large scale hydro electric projects and the transmission of power over long distances are technically feasible, the power potential of the Cowichan River is insignificant. It is unlikely that the small dam sites which were suited to development in the early days of electrification will now be required as an energy source. Thus the hydro electric power potential of the Cowichan River is no longer of significance in the resource base of the watershed.

Thermal electric power generation is conducted on a small scale in the Cowichan basin for use at Youbou, Mesachie Lake and Honeymoon Bay. Youbou and Mesachie Lake use wood waste as fuel to generate 4300 and 2610 kw. respectively. Honeymoon Bay uses an oil fuel to produce 3000 kw.[18] The greatest proportion of water withdrawn for industrial purposes by these three communities is used to generate power. This water, when it has passed through the condensers, is discharged into the lake. In sufficient concentrations, water discharged from thermal

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[17] Loc. cit.

[18] Canada, Department of Northern Affairs and National Resources, Water Resources Branch, Electric Power in Canada, British Columbia, Yukon and Northwest Territories, Ottawa, 1965, p. 6.

power generating units can warm up a waterbody so that the environment for aquatic life is altered and the existing species disappear. At present there is no threat to the biotic community of the lake from this warm water as it is such a small proportion of the total volume of the lake. Should thermal electric power generation be undertaken on a large scale at some future time, or should a generating unit be installed on a sheltered part of the lakeshore, the accumulation of warm water could affect the existing aquatic life.

Fish

At one time the fish population of the Cowichan basin was reduced to a point approaching extinction. Deforestation by the logging industry disrupted the flow regime to produce flash floods in the winter season and extremely low flows in the summer.[19] The floods scoured the spawning beds and destroyed aquatic life. Summer droughts left fingerlings stranded and further damaged the biotic community. Natural regrowth of the forest and changed cutting practices, in combination with the installation of the weir at the mouth of Cowichan Lake, have led to an improved flow regime and a

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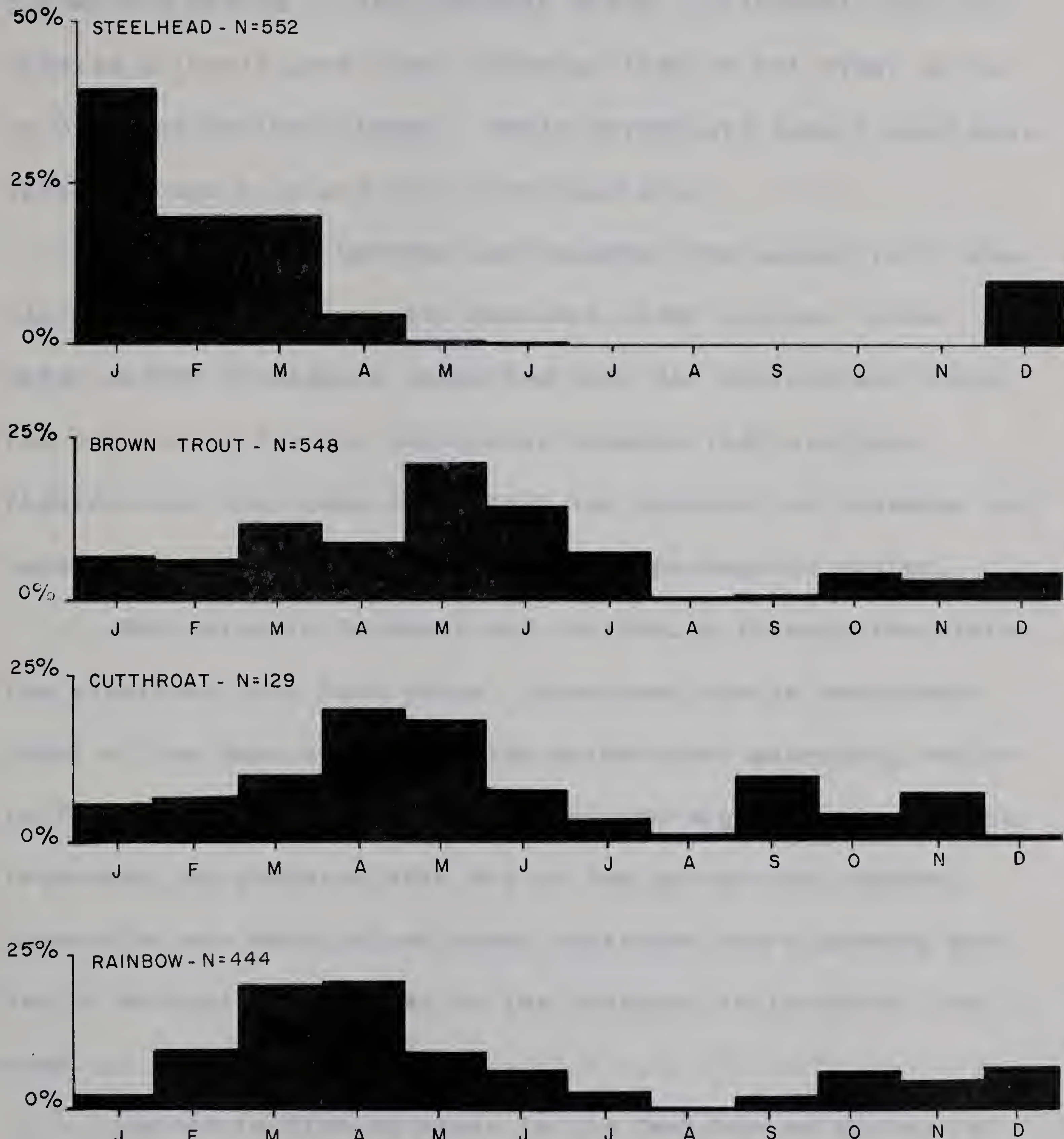
[19] Pers. Comm., R.C. Thomas, British Columbia Department of Recreation and Conservation, Fish and Game Branch.

renewal of the fish populations.

The Cowichan basin is now important in the food and sport fishery of British Columbia as a spawning and rearing area for several species of salmon and the home of several varieties of trout. Spring, coho, pink, chum, and sockeye are the five major salmon species which home to the Cowichan watershed in the fall or winter to lay their eggs and die. These fish are caught commercially only at sea. Sport fishing for salmon is also conducted mainly at sea. Only the Indians take salmon in fresh water to any extent. A few fishermen may try for them in the non-tidal waters of the Cowichan during the salmon runs in the fall, but their flesh is not generally prized at this time in their life cycle. Trout are of interest to the freshwater sport fisherman. In the Cowichan, rainbow trout, cutthroat trout, Dolly Varden, brown trout and the anadromous steelhead form the basis of a popular sport fishery resource. There is no commercial fresh water fishery.

Sport fishing is conducted all year on the main stem of the Cowichan River (Fig. 29). The first species to appear in the fisherman's creel in the spring is the brown trout, and it continues to provide good fly fishing in the summer when other fish may be more elusive. Brown trout were introduced into the Cowichan River and Cowichan Lake in plantings

MONTHLY DISTRIBUTION OF FRESH-WATER SPORT FISH CATCH, 1962 TO 1965



Source: C.J. Bull, The Distribution, Growth and Food of Angler-Caught Trout in the Cowichan River, Victoria, 1966.

Fig. 29

from 1932 to 1935. Other species of trout are also fished in the spring and summer. Rainbow trout, cutthroat and Dolly Varden are native to the Cowichan River. Cutthroat are considered valuable game fish, although they do not break water as often as do the rainbow. Dolly Varden are also a good game fish although they are not noted fighters.

Between October and December the salmon runs take place from the sea into the Cowichan River system. Fresh water salmon fishing is permitted only for springs and cohos. The coho are prized in particular because they are good fighters and they come later than the springs, in November and December, when the river is higher and passage is easier.

Beginning in December and continuing through the winter, the steelhead runs take place. Steelhead are an anadromous trout of the same species as the rainbow but averaging twelve to fourteen pounds on the early runs and eight to nine on the late ones, as compared with one or two pounds for rainbow. These fish are much prized among sportsmen and a growing number of enthusiasts journey to the Cowichan to intercept the runs.

Access to fishing areas in the Cowichan watershed is not uniformly good. Along the lower reaches of the Cowichan River, Indian lands border the stream. The Indians sell a

\$6.00 licence for the right to fish on their lands. This is ineffectively administered, and abuses of the licensing system have discouraged some anglers from using this section of the stream.

Upstream from Duncan, the land is held by the government in forestry and recreation reserves, by several logging companies, and by private owners. Present access to the river for fishing is best around Skutz Falls (Photo 5) and downstream from the Village of Lake Cowichan. To improve access and to ensure its maintenance against future population pressures, the local Rod and Gun Club has begun constructing a footpath to Skutz Falls along the southern side of the river. Originally the path was to begin at Duncan, but rights were denied on Indian lands, so it commences at Deerholme. The private lands in the lower reaches are skirted by the path, and a mile and a half section belonging to Macmillan and Bloedel Company Limited is not traversed. The path was designed to follow the top of the river bank and have feeder trails down the banks to the fishing pools. A foot bridge has been constructed across the river just below Skutz Falls to link the trail to the Cowichan Lake road. It is proposed that the path be continued on the north side of the river from

Skutz Falls to just outside the Village of Lake Cowichan.[20]

The Koksilah River has the same species as the Cowichan River to entice the sports fisherman. It is not so well known outside the area as is the Cowichan, and access is not so easy. Wild Deer Lake on the Koksilah has been stocked with trout in the past and has recently been restocked. The fish leave the lake to spawn and then cannot climb the rise back into the lake to reproduce their populations. Access to the lake and to much of the Koksilah is through the bush, an aspect which appeals to the more independent fisherman.

Cowichan Lake is a popular area for summer trout fishing. Marinas and boat rental services are available to the angler at the Village of Lake Cowichan. There is a boat launching ramp at the British Columbia Forest Products Company Limited camp ground near the head of the lake.

Quamichan, Somenos and Crofton Lakes have trout populations which attract the sport fisherman. Quamichan Lake is stocked every three years, while the others depend upon natural regeneration. Access to Quamichan and Somenos Lakes is limited because most of the shoreline is privately owned, but there are public boat launching facilities on each lake.

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[20] Pers. Comm., Mr. Williams, Rod and Gun Club, Duncan.

Fishing is now being discouraged on Crofton Lake because it is used as a public water supply. Mayo Lake near Skutz Falls has been stocked as a children's fishing pond by the local Rod and Gun Club. Access to this area is no problem.

Local people are the most numerous users of the fishing grounds in the Cowichan basin. Visitors from Victoria and Nanaimo, and from Vancouver form a significant proportion of weekend and holiday fishermen. During the steelhead runs in the winter, anglers may come from the United States as well.

There is some conflict between the fishery of the Cowichan River basin and the forest products industry. The manipulation of the weir on Cowichan Lake by the British Columbia Forest Products Company Limited is upon occasion carried out in such a way as to endanger the fish populations. Rapid adjustments in the flow rather than gradual changes over several hours can strand fry when the flow is suddenly diminished and scour gravel beds when it is suddenly increased.

Pollution from industrial wastes is not presently a problem in the Cowichan basin, but should there be any change in the character of the forest products industry in the area, as for example, more emphasis on chemical processing, one could quickly develop. The provincial Fish and Game Branch, and the Pollution Control Board maintain some vigilance over

industrial pollution of streams. The Fish and Game Branch is particularly interested in pollution which threatens fish populations, while the Pollution Control Board is concerned with industrial effluent and stream chemistry.

There is a potential conflict between the fishery of the Cowichan River and possible flood control measures to be undertaken in the future. The present measures for flood control; that is the weir on Cowichan Lake and the annual dredging of the lower reaches of the river, have been undertaken so as to minimize the effects upon the fish. The weir is equipped with fishways to facilitate the passage of fish from the lake to their spawning beds in the river, and back again. The time of dredging has been scheduled for the low water period in September, when access to the river is easiest and the number of fish eggs maturing in the gravel is likely to be low.

Future flood control measures would be of a different type from those already undertaken, and might have a more deleterious effect upon the fish. The PFRA report on flood control contained a recommendation for cutoffs to increase the river gradient and thus carry off flood waters more rapidly. It seems likely that these would be a major part of any flood control scheme undertaken for the Cowichan River

basin. Cutoffs could leave either dry or as stagnant back-waters, sections of the stream where presently trout and salmon annually spawn. They might also block the fish from access to gravel beds at the mouths of creeks tributary to the cutoff sections, where a good percentage of spawning may actually take place. Patterns of spawning for trout and salmon are not fully understood, so the exact effect of stream cutoffs upon the sport fish populations cannot now be ascertained, but it is certainly a factor to be considered in the evaluation of any flood control scheme.

On a small scale, conflict exists between fishing for recreation and the provision of water for public consumption. When the source of water is as small as Crofton Lake, public officials tend to discourage use of the water body by sportsmen other than residents of the lakeshore. This has indeed happened to the once popular fishery on Crofton Lake.

The conflict of fish and water power found on so many west coast streams does not apply to the Cowichan system, as there has been no development of hydro-electric power generation, nor is there likely to be. The addition of large thermal electric power generating plants to the power grid of the basin could affect the fish populations by warming the water with their effluent so that the fish and the food upon

which they now depend could not survive. Such a situation is remote in view of the excellent hydro-electric power potential of the province of British Columbia.

The fishery of any stream tends to be given secondary consideration in the development or regulation of the water resource. In British Columbia conservation[21] ranks tenth among thirteen water uses. This may be because fish were for long considered an indestructable resource. Now it is realized that they are a delicate organism which cannot be abused by water pollution, removal of spawning beds, or obstructions of the river channel, and still be expected to thrive. Despite this realization little consideration is given to measures protecting the fish when planning for river development. The plea of the fisheries biologist is frequently ignored, perhaps because it has become so familiar to the planner and the engineer. A second look at project plans to consider modifications or the introduction of special provisions to ensure the protection of fish, should be a standard procedure in the development of any project. To present plans to the fisheries biologist with a "like it or not" attitude is

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[21] Conservation under the Water Act is "the use and storage of water or the construction of works in and about streams for the purpose of conserving fish or wildlife."

nearsighted. The biologist on the other hand, should be prepared with concrete information on the habitat and life cycle of the various species in a river and the likely effect of planned changes in the river, so that alternate ones may be suggested. By working together, the interests of both could be served, and through them those of the community.

The Cowichan River provides a diverse and exciting sport fishery within easy access of the large centres of Vancouver Island and the mainland. The preservation and development of this resource will ensure an important recreation outlet for the growing population of the west coast.

Wildlife

The wildlife population of the Cowichan River basin includes game animals and birds, large wild animals, and fur bearing animals. The uplands of the Cowichan valley are one of the best known areas for deer on Vancouver Island.[22] Hunting is conducted in the logging areas from Deerholme to the head of the lake. Logging roads provide ready access to much of the deer habitat. The deer, although an enticement to the hunter, can be a threat to the reestablishment of vegetation on logged over areas, as they browse among seedlings and young

[22] Pers. Comm., Jack Fox, Conservation Officer, Duncan.

trees, destroying buds and bark. Upland game birds are also found on the logging areas. Blue and willow grouse are the species most frequently hunted. At Cowichan Bay, pheasants, ducks and geese attract the hunter. Water-fowl were once plentiful on the coastal plain, but their numbers have decreased since the drainage of land around Somenos Lake, and the implementation of flood control measures along the lower Cowichan have removed some of their nesting areas.[23] The large wild animals in the area include wolves, bear and cougar. Marten, weasel, mink, muskrat and beaver are some of the fur-bearing species.

Wildlife is a minor consumer of water within the Cowichan basin, but it is part of the ecological balance of the forested regions, and it serves to attract hunters and nature-lovers to the area. Wildlife depends upon a steady supply of pure water for its survival. Denudation of slopes by logging or fire can result in changed runoff regime, so that streams dry up completely during the summer. Without water the animals are then forced to move elsewhere or face death. Forest fires too, can rout animals from an area. For water-fowl, flood control measures which might effect a change in the

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[23]Pers. Comm., Hugh Sparrow, Fisheries Research Board, Nanaimo.

nature of the surface water bodies upon which they nest are a threat to their existence. No measure can be placed upon the value of the wildlife population of an area because it does not become valuable until it has disappeared. The Cowichan basin appears to have a healthy wildlife population, partly as a result of strict enforcement of game laws. It is important that it be retained for the future.

Recreation

Since the Second World War there has been a spectacular increase in the demand for outdoor recreation facilities. This is related to the shorter work week, the paid vacation, improved transportation, and the growth of cities, the major source of this demand. It seems likely that this trend will continue, although perhaps not at the same rate as in the recent past.[24] New facilities must, therefore, be continuously set aside for public use.

The amount of use a particular site receives is dependent upon the availability of alternate sites with the same facilities.[25] Much of southern Vancouver Island, because

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[24] Marion Clawson, "Recreational Resources" in Guy-Harold Smith (ed.), Conservation of Natural Resources, New York, 1950, p. 442.

[25] Ibid., p. 449.

it is held under the Esquimalt and Nanaimo Railway Land Grant, is closed to public or private development of recreation facilities. Access to these areas, used primarily for logging, is limited to weekends. Their use for recreation without the development of facilities, is restricted to driving, hunting, or hiking. These lands might be suited to semi-wilderness use, "...which provides a refuge from mechanized recreation but permits some logging and other uses",[26] except that logging has so extensively modified the countryside and overnight camping is discouraged by the logging companies. Thus the scenic areas on the east coast of Vancouver Island assume a greater importance for recreation than would otherwise be the case. One provincial park has been established near Victoria, and others have been developed on the central part of the island north of Nanaimo. The southeast part of Vancouver Island, where there is the greatest concentration of urban population and which is closest to the large centres of the mainland, has little developed park land.

The Cowichan basin, with its large lake and two main rivers, is well endowed with outdoor recreation sites. It is

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[26]Robert C. Lucas, "Wilderness Perception and Use: The Example of the Boundary Waters Canoe Area", in Ian Burton and Robert W. Kates (ed.), Readings in Resource Management and Conservation, Chicago, 1960, p. 364.

favourably situated to service the recreation needs of Victoria and Nanaimo, being about an hour's drive from each, and within four or five hours travel time, via ferry and road, from Vancouver.

Water is an important resource for outdoor recreation. It provides for such activities as swimming, fishing, and boating, as well as enhancing a naturally beautiful picnic or camping site. Lake Cowichan is one of the largest and most attractive water bodies on Vancouver Island;[27] the rivers too, are scenic and well known for their fishery resource.

Measuring recreational use of a land area has always been a problem. Labourious car counts and questionnaire surveys are the usual devices used to determine the number of tourist visits. The Duncan Chamber of Commerce maintains a tourist information centre for the Cowichan valley on the Island Highway which has kept statistics of inquiries for the last few years. The number of calls at the tourist bureau is an indicator of interest in the Cowichan area shown by people not already familiar with it. The many visitors who already know the area, or who have received information on the ferrys

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[27] G.F. MacNab, Cowichan Lake Proposed Park, British Columbia Department of Recreation and Conservation, Parks Branch, Victoria, 1962, p. 4.

when they debarked at Victoria or Nanaimo, will not be recorded by it. In 1964 and 1965 there were a total of 3,067 and 3,829 tourist calls respectively at the office. The greatest proportion of these were made in July and August, although there were a significant number of visitors in June and September.

The community of Cowichan Bay is a recreation centre for marine salmon fishing. There are boat rental facilities, mooring facilities, tackle shops, and a motel which cater to the fisherman. On any weekend during the salmon season, cars can be seen lined up the full length of the road through the community, their owners out in the Bay trying their luck (Photo 14). The early fall brings particularly good fishing, as the salmon are collecting in the Bay preparatory to moving up the river to their spawning grounds. This is a favourite time for fish derbies.

Facilities for small boat owners, unlike those for large boat owners or those without boats, are not adequate at Cowichan Bay. A popular activity for many enthusiastic fishermen is to drive to a fishing area on a summer evening or on a weekend and, using their own boat, spend a relaxed time on the water. Cowichan Bay is ideally suited with respect to Victoria for this type of recreation. There is, however, no

public boat launching ramp at present. Just north of the community a clear piece of shoreline is used for boat launching, but it is makeshift with no parking facilities and no adequate approaches (Photo 15).

In 1959 the "foreshore and land covered by water in Cowichan Bay"[28] including the makeshift ramp site, was reserved for recreation use by the Parks Branch. This means that the land is withheld from sale, lease, or other alienation. The purpose of the reserve was for future use as a boat launching site. The reserve does not authorize development or use of the land as a recreation area, but it does ensure that development will be possible on that site when finances and population pressures warrant it.

This site is not now considered suitable for the development of boat launching facilities. The area is a narrow strip of shoreline bordered inland by the road and a steeply rising terrace. Parking space is thus limited. To create adequate parking facilities, part of the terrace would have to be excavated. Expensive construction measures are not usually favoured in park development, so the project might be abandoned. A second difficulty in the development of the site

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[28]British Columbia Department of Recreation and Conservation, Parks Branch, File No. 111-75, Victoria.

is the use of Cowichan Bay for log storage under a booming lease. It is felt that the industrial use of part of the Bay might conflict with recreational use. This site is valuable, even though it may not be completely satisfactory for the purpose outlined, because it is close to the fishing centre of Cowichan Bay and no other sites are available.

Elsewhere along the waterfront facing the Straits of Georgia, the more attractive sites are already in residential use and therefore not available for public recreation. The estuary of the Cowichan River is not suited to park use, and Indian reserves and industrial use have already claimed the land around the Bay. North of Cowichan Bay the coast is rocky. Where the shoreline is wide enough to permit settlement, as at Maple Bay, the land along the Straits has been devoted to residential use. Near Crofton there is an excellent sand and gravel beach along the shore with clean shallows off shore. Some land has been considered for park reserves in this area but the average available is small and there is fear of pollution by the effluent from the mill at Crofton.[29]

Along the coastal plain, the major tourist feature is

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[29] R.H. Ahrens, <u>Reconnaissance For an Ocean-Front Park on Southeastern Vancouver Island and Report on Evening Cove Park Proposal</u>, British Columbia Forest Service, Park and Recreation Division, Victoria, 1955, p. 15.

the scenic drive along the old Island Highway from Cowichan Bay to Crofton. This two lane paved road winds its way along the coast offering scenes of the Gulf Islands, prosperous farmland, and attractive forest. While they are in the area, tourists frequently take industrial tours of the sawmills and the pulpmill. The Forest Museum on Somenos Lake, featuring the logging history of British Columbia, is another popular attraction.

Facilities for swimming and picnicking within easy access of the Island Highway and Duncan, are lacking. The nearest provincial park facilities are almost half an hour's drive away and take tourists out of the valley. There are a few picnic tables at Maple Bay, and swimming facilities are available there and at Crofton, although the water is too cold for many. North of Maple Bay a picnic site was set aside on Maple Mountain overlooking Crofton and the Gulf Islands to mark the 1958 British Columbia Centennial. The steep road to the site is deteriorating and discourages tourist travel. The site itself is not developed, although it has great potential as a scenic picnic spot. Along the lower Koksilah there are some pools which might be developed for swimming and wading, but during the low water of the summer they are only a foot or more in depth rendering them suitable only for use by

small children. On the southwest shore of Quamichan Lake a small park has been developed by a local service club to provide picnicking and swimming facilities. This appears to be designed mainly for use by local residents as its location is not indicated by road signs nor is it advertised by the tourist bureau.

There are no developed swimming sites along the lower Cowichan. One of the possibilities of a flood control scheme would be the excavation of the island created by a meander cutoff to provide a pool for swimming in the river near Duncan. In the development of a site close to Duncan, conflict between the various administrations in the area might be a deterrent. A spit near Duncan was considered by the Parks Branch for a picnic, swimming, and fishing site to provide access along the lower reaches of the Cowichan where it is restricted by Indian lands. Part of the land was found to belong to the city of Duncan and therefore was not suitable for a provincial park. The land has since passed into other hands, even though its value for public access and the need for this access was recognized by provincial officials.

On the main stem of the Cowichan, the physical resource for recreation is abundant. Most of the river valley is free from residential use. Although access is limited, there are

many sites suited to fishing, swimming, picnicking, and camping. Little has been done to develop these sites even though, where possible, they are being used by local and visiting fishermen and their families.

The local Rod and Gun Club has sought to establish a fisherman's trail along the river, and they have enlisted the aid of the Parks Branch in reserving the land adjacent to the river for perpetual use. The Parks Branch has agreed to establish reserves on all Crown lands suitable for access because of the value of the Cowichan as a fishing stream, and because of past losses of public access to other rivers.[30] The reserves are not continuous along the river. According to Table VIII which lists the tenure of river frontage, less than one quarter of the total frontage is held by the Crown. To acquire a continuous strip along the river would be a costly undertaking, so the Parks Branch policy is to methodically purchase river frontage as it comes on the market until a substantial portion of the river is available for public use.[31]

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[30] British Columbia Department of Recreation and Conservation, Parks Branch, File No. 111-326.

[31] British Columbia Department of Recreation and Conservation, Parks Branch, File No. 111-84.

TABLE VIII

COWICHAN RIVER FRONTAGE[32]

	Frontage Ft.[33]	Miles	Percent
Total River Frontage, Lake to Ocean on both sides, including river bends but no side channels	333,400ff	63.1	100
Total Crown Frontage	68,500ff	13.0	20.5
Vacant Crown Land	9,400ff	1.8	
Reserved for use and enjoyment of public	14,050ff	7.7	
Island Plantation Forest Reserves	32,950ff	6.2	
Private land being purchased as park	12,100ff	2.3	
Indian Reserve Land	92,950ff	17.6	27.9
Privately Owned Land	171,950ff	32.6	51.6

Several park reserves have been set aside along the Cowichan River (Appendix IV). These appear as areas of outdoor recreation on the land use map (Fig. 6). Although all the land reserved for recreation purposes along the Cowichan

[32]British Columbia Department of Recreation and Conservation, Parks Branch, File No. 111-326.

[33]Figures unreliable except total river frontage, Indian reserve frontage and Island Plantation frontage. Dated to February 24, 1964.

River is valuable for the access it provides to the river, some of it is better suited to development in light of the particular needs of the area than others. The area upstream from Deerholme, the site at Skutz Falls, the Rip's Road Picnic Site downstream from the Village of Lake Cowichan, and the reserve at the downstream end of Marie Canyon stand out for their recreation potential as priority sites for development. The first three could be developed to provide fishing, swimming, picnicking, and, in the case of Skutz Falls, camping for local people and for visitors, at widely separated points along the river. The fourth site is suited to specialized development as a campsite with foot access only, to service fishermen and hikers using the Rod and Gun Club trail.

Cowichan Lake has outstanding potential for recreation.[34] Its long irregular shoreline with extensive undeveloped gravel beach frontage and its warm water are suited to fishing, boating, swimming, camping and picnicking. The waters are presently used by logging companies on the lake for hauling, booming and storing logs (Photo 1). The Esquimalt and Nanaimo Railway, under its land grant, owns the lake bottom, so that conflicts may exist in many cases between the

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[34] G.F. MacNab, _op. cit._, p. 4.

use of beach and fishing areas by tourist or by logging companies who now have timber and access rights.

Because of the use of the hinterland for logging, access to the north shore of the lake beyond Youbou is difficult. The British Columbia Forest Products Company Limited at Youbou used to open the gate to the logging road once an hour on the hour. In the summer of 1966, the logging road along the north shore was closed because of a washout. The logging companies are reluctant to open up the land to tourists where it is possible to reduce access, because of the potential fire danger created by visitors. Along the more accessible south shore of the lake, these companies have attempted to provide some recreation facilities to service their own employees and to reduce the movements of visitors within the area. Although the south side of the lake is less favoured for recreation purposes than the north side because of its cold northern exposure and the generally poorer sites for park development, several sites are now in use and others have been reserved.

Three park sites have been developed along the lake by the logging companies. At the mouth of Sutton Creek, just beyond Honeymoon Bay, Ashburnham Beach has been developed as a swimming and picnicking site by the Western Forest Industries

Company Limited of Honeymoon Bay. Farther along the shore, east of Caycuse, a campground and picnic area with swimming facilities, and a boat launching ramp have been developed by the British Columbia Forest Products Company Limited for tourist use (Photo 16). Although developed with care and forethought, the site has a northern exposure and is heavily forested, so it tends to be cold and damp. A beach and camping area at the head of the lake has been set aside by Crown Zellerbach Company Limited for use by its employees from the logging camp at Nitinat, just west of the Cowichan basin.

Among the park reserves on Cowichan Lake, Lakeview Park on the south shore, west of the village of Lake Cowichan, and Gordon Bay, beyond Honeymoon Bay, have been partially developed. At Lakeview Park, the stony beach has been cleared and some facilities for diving and water skiing have been installed by the local Kiwanis Club (Photo 17). A camp ground was under construction in the summer of 1966. When this is completed the site will be fully developed for public use, both local and visiting. At Gordon Bay, picnic tables and garbage cans were installed in the summer of 1966. The area is already in use for picnicking and camping, although adequate clearing and development of the site has not taken place. With further development this could be an excellent

recreation attraction, as the view from the park is exceptionally beautiful (Photo 18) and the site is cool and peaceful.

On the north shore of the lake, on the deltas of Cottonwood, Wardroper, and Shaw Creeks, the acquisition of large acreages for the development of day and overnight resort use to service the population of Vancouver Island has been considered by the Parks Branch. The possibility of future day use by people from Vancouver was also considered for these sites. If developed, these sites would provide swimming, fishing, picnicking, nature study and camping attractions. Since the present access by private logging road would not be suitable for a large campsite designed for heavy use, nothing has been done to reserve these lands. It may be that, when a shortage of similar large acreages elsewhere on southern Vancouver Island develops, they may be considered once again for park use. If it were not for access problems any one of these sites would be an excellent addition to the recreation facilities of the area.

The demand for recreation on southeast Vancouver Island, by people from Victoria and the mainland, is growing. As has happened elsewhere in North America, park sites for camping and picnicking, and river access for fishing will soon be at a premium on the west coast. Plans should be made now to

reserve and develop land suited to outdoor recreation. The Cowichan basin, in particular, is well situated and has many excellent sites to service future recreation needs. Heavy use is already being made of any site in the basin with suitable access, regardless of its state of development. To better meet demands, both present and future, overall planning for development of recreation facilities in the Cowichan basin, and further acquisition of land for park purposes is an immediate necessity.

Navigation

Minor use of the waters in the Cowichan River basin is made for navigation. Logs were driven down the Cowichan River until 1909 after which time they were transported by the Esquimalt and Nanaimo Railway. The river is too shallow during the summer to be used extensively for boating. The large lake and the open expanse of the sea are much more attractive to the boating enthusiast than the river. The lake can be hazardous for small boats because of its size but fishermen and pleasure seekers do use it throughout the summer. Local residents living along the lake or upper river may use a small boat to travel to work at one of the sawmills along the lake. The boat lock in the weir was installed to accommodate this and other local travel. At present the only commercial

use made of the Cowichan waters for transportation is the towing of logs from their point of assembly at the logging camp at Caycuse to the sawmill at Youbou.

CHAPTER VI

CONCLUSIONS

The Cowichan River basin is well endowed with water and related land resources. Problems of water allocation and development have led to some conflicts between users. Rather than small scale projects designed to solve these problems individually, the most important requirement for the Cowichan River basin at this stage of its development is further research to delimit the resource base, and regional planning to effectively coordinate the growth of the many facets of the region.

In undertaking a study of the water resources of the Cowichan River basin, the need for specialized research in a number of areas, some academic and others intensely practical, became apparent. The physical resource base is imperfectly known. Geologic mapping is yet to be completed. Clapp's work,[1] undertaken in the early 1900s covers most of the

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[1] C.H. Clapp, Sooke and Duncan Map-Areas, Vancouver Island, Canada, Department of Mines, Geological Survey, Memoir 96, Ottawa, 1917, 404 pp.

coastal lowland, and Fyles' 1955 study[2] extends to the lake region. The boundaries of their maps do not meet and some of the interior uplands have yet to be mapped. Information on the glacial geomorphology of the area is fragmentary. A preliminary map of the surficial geology has been completed for the coastal lowland by Halstead.[3] Information for this is incomplete and the map could be extended to the lake region.

Although there are many areas of research on the water itself, several stand out in particular. More detailed knowledge of the groundwater resource is necessary to complete the water inventory of the basin. Well logs, although valuable, supply only scanty data and should be supplemented by further research. A meteorological station should be installed in the mountains, and one or more of the mountain streams should be gauged, so that the contribution of moisture from the upper watershed may be better understood, particularly with relation to flooding in the lake. Research into the spawning habits of trout and salmon in the basin and the ecological balance of

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[2] James T. Fyles, Geology of the Cowichan Lake Area, Vancouver Island, British Columbia, British Columbia Department of Mines, Bulletin No. 37, Victoria, 1955, 72 pp.

[3] E.C. Halstead, Surficial Geology of Duncan and Shawnigan Map-Areas, British Columbia, Geological Survey of Canada, Paper 65-24, 1966, 3 pp.

the fishery resource now being undertaken, should be continued in light of the growing importance of recreation in the basin and potential conflicts with flood control schemes. In undertaking any of these projects, more areas of research need will undoubtedly emerge.

As well as research to further the understanding of the resource base of the Cowichan watershed, some planning should be undertaken, so that conflicts now existing between some of the potential sources of revenue in the area may be reduced, and some of the present haphazard development may be more efficiently directed. The Cowichan River basin has a variety of resources upon which to base its development; a scenic waterway rich with fish as its backbone, a luxurious forest suited to large scale exploitation in the upper basin, and fertile agricultural lands in the lower basin. Prosperity and growth have come to the valley. In order to foster this, some planning for future development is a necessity.

The resources of the basin are divided between those customarily managed by business interests and those overseen by conservationists. Traditionally, agricultural, industrial and urban interests have provided the income for the area while recreation has made only a minor contribution. Increasingly, however, recreation is becoming a major source of

revenue for the basin. With regional planning, recreation can become a cornerstone of increasing prosperity.

Recreational use of natural resources tends to exclude other uses from an area. In some cases this exclusion is on a large scale while in others it may involve the alientation of only a small portion of the land resource. The sport fishery is one of the more exclusive of the recreation resources. Conflict between the forest products industry and the preservation of fish for recreation use with respect to water quality and river regime has already been cited. Flood control measures to preserve urban and agricultural interests, may also conflict with the development of sport fishing by reducing spawning grounds. River and lake access to fishing areas, requiring attractive settings, each with facilities for parking, picnicking, and for some, boat launching and camping, may conflict with the land uses of the basin, which also desire water frontage.

Park development is a less exclusive recreation facility. Parks do require attractive settings suitable to development of parking, picnicking, camping, and where possible, swimming facilities. A park is limited in area and may be developed adjacent to agricultural, residential, urban or industrial land use depending upon the type of park, and providing there

is an adequate buffer of land between the areas, to prevent conflict between the users of each. Access to parks should be clear, but it may be through land utilized for other purposes. In the Cowichan basin, access to several potential park sites is through land held for forestry purposes. The need of the forest products industry for a protected forest to minimize fires, has led to some conflict with park development. As the pressure for recreation facilities increases, this conflict will become more pronounced.

Some development of the recreation resource, public and private has taken place in the basin, but except for the Parks Branch policy to acquire a more or less continuous strip of river frontage to provide public access, nothing has been done to guide development of the lands acquired along the river or around the lake. A large scale study is necessary to determine requirements for land and facilities for recreation on Vancouver Island over the next twenty years. A more detailed study of how the Cowichan basin might be developed to meet some of these needs for day and overnight resort use should then follow. If a blueprint of acreages and types of development required to service recreation requirements were available, local organizations, realizing the potential value of recreation if given a proper place in the economy, and their own

needs for recreation, might contribute to these needs as has already been done at Maple Mountain, Quamichan Lake, Lakeview Park, and along the river in the Rod and Gun Club Trail.

Other areas of haphazard development occur in urban and agricultural land use. The steady growth of population in the Cowichan basin has resulted in larger urban and rural non-farm agglomerations. Farm land is being held as a speculation in hopes of subdivision at high prices which automatically remove it from the possibility of future agricultural use. Small subdivisions and ribbon developments are demanding expensive water services. In addition, urban expansion is extending into flood prone areas along the river. Planning for orderly urban growth onto land less suited for agriculture, and skirting flood prone areas which would require costly protection schemes or regular repairs of flood damage, is needed to prevent small scale urban sprawl and unnecessary outlay of public money for subsequent servicing.

Agriculture in the Cowichan basin is presently scattered over the coastal plain. Farming techniques are efficient, but costs are high. Irrigation facilities are needed by many farmers to improve yields and reduce costs. Competition by encroaching urban development is raising land prices and preventing some farmers from expanding their holdings. A regional

survey which would evaluate the most fertile land in the basin and that most easily serviced by an irrigation scheme should be undertaken. A suitable area, or group of areas, could then be set aside for agriculture with future urban use restricted. Once the farming areas were consolidated, local irrigation schemes to improve pasture and hay crops might become economic, so that, although acreages might be reduced, production would be greatly increased.

The resolution of conflicts between present land uses in the basin and the directed development of certain of these, demands a planning authority for the valley and its environs. The present administrative structure in the basin consists of the councils of the District Municipality of North Cowichan, Duncan and the Village of Lake Cowichan, and the Federal Indian Affairs Branch on the Indian lands. Large areas are not administered by any authority other than the provincial government which cannot oversee all facets of local development. This has resulted in such incongruities as use of the improvement district provided for under the Water Act to furnish everything from hospital services to electric lights. In eastern Canada, local administration and planning is done through councils of the smaller units of the county and township. In British Columbia, this intermediate level of

government is absent. Institution of it has been suggested, and the population concentrations and the rate of growth on the coastal plain of Vancouver Island certainly seem to warrant it.

In the Cowichan basin an intermediate administration with powers of planning for and servicing the unincorporated areas of the basin, and of working with the incorporated ones, would be valuable in realizing the potential of this resource rich area. A regional unit spanning the east coast from the Malahat to Nanaimo, and providing for internal subdivisions for local administration would allow integrated planning for this portion of the east coast of Vancouver Island and ensure wise and ordered development of the resources of the Cowichan basin.

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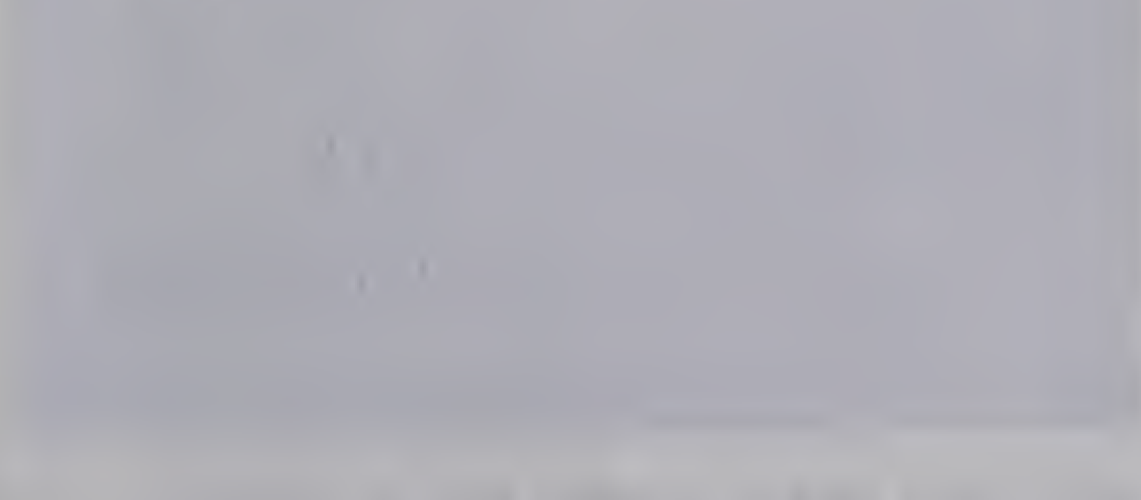

Photo 1. Cowichan Lake looking east from the log booming area at Caycuse. Note the low shore at the right and the mountains in the distance.

Photo 2. A portion of the steeply rising north shore of Lake Cowichan. The runoff channels probably follow skid trails gouged by original logging activities.

Photo 3. Cowichan River upstream from Skutz Falls. Note the dense growth of broadleaf maple along the river and the abundant logging debris in the channel.

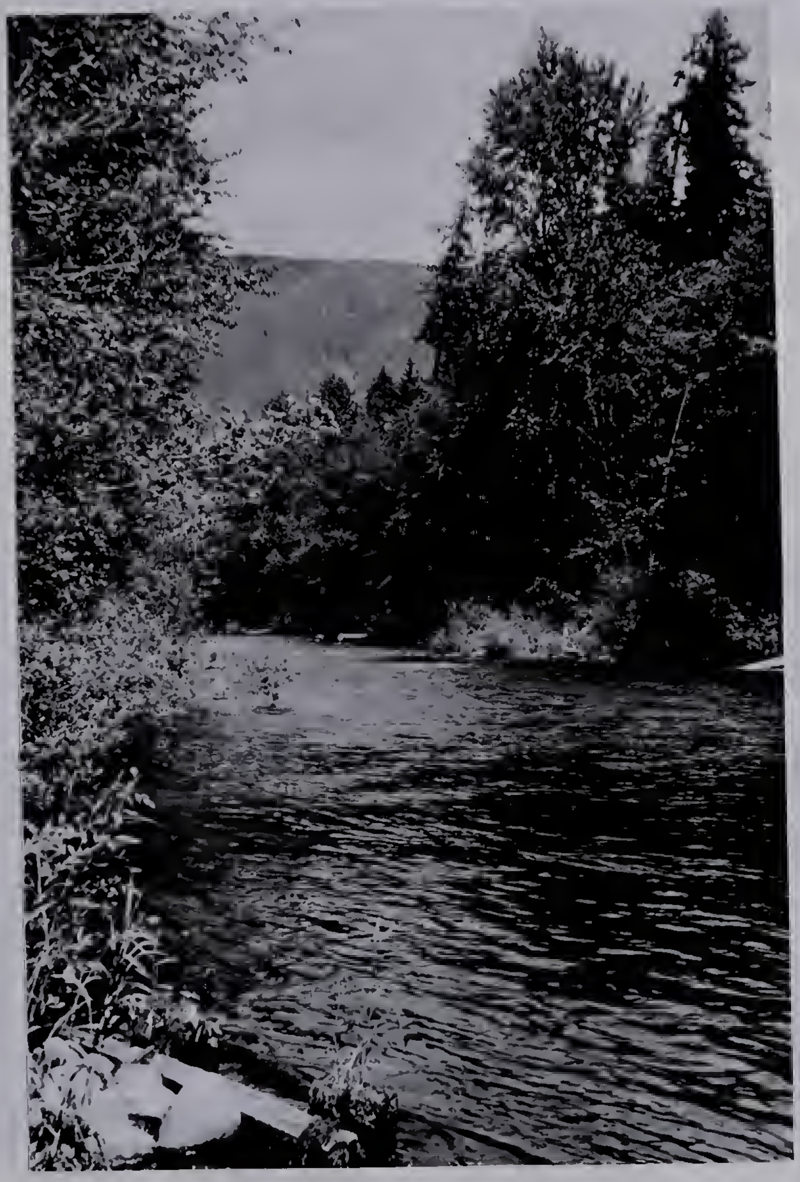

Photo 4. Cowichan River looking downstream from the railway bridge midway between Cowichan Lake and Skutz Falls. Thick second growth vegetation extends to the water's edge.

Photo 5. Cowichan River looking upstream at Skutz Falls. The river is incised in shale bedrock. Fish ladders have been constructed to the right of the falls to permit easy passage of spawning salmon. In the Skutz Falls area sport fishing is popular.

Photo 6. The Cowichan River downstream from Marie Canyon. Note gravel bed material, low banks and meandering course. Hills flank the narrow valley.

Photo 7. Cowichan River at the power line crossing the river between Holt Creek and Duncan. Erosion is proceeding actively into a bank of unconsolidated materials.

Photo 8. A view of the coastal plain from Mount Prevost. Quamichan and Somenos Lakes are to the left, Cowichan Bay and the Straits of Georgia in the distance, and Duncan on the right border.

Photo 9. Cowichan River near its mouth showing a bank subject to erosion during flood.

Photo 10. A thirty year old stand of second growth Douglas fir. The mountain in the background has been denuded of vegetation by logging and little regeneration has occurred.

Photo 11. A logging road south of Cowichan Lake. Patch logging can be seen in the background. In the foreground the forest has been cut and the slash burned. The road cut is a site of potential erosion.

Photo 12. The weir at the mouth of Cowichan Lake showing the spillway gates on the left and the boat lock on the right.

Photo 13. Cowichan River below Duncan. Gravel banks at the right have been built up by dredging as a flood control measure.

Photo 14. A view of the community of Cowichan Bay looking north. The cars belong to fishermen using the facilities of this resort community.

Photo 15. Makeshift boat launching facilities north of the community of Cowichan Bay. The Bay in the distance is used for storage and shipment of logs.

Photo 16. The beach at the British Columbia Forest Products Company Limited campsite on Cowichan Lake near Cayuse. The site has a northern exposure and is cold and damp.

Photo 17. The newly developed swimming facilities at Lake-view Park on Lake Cowichan.

Photo 18. The view of Lake Cowichan looking east from the park at Gordon Bay.

APPENDIX I

SOIL ASSOCIATIONS

APPENDIX I

SOIL ASSOCIATIONS

Parent Material	Soil Type	Texture	Profile	Drainage	Permeability	Soil Moisture Storage Capacity for Eight inches of soil	Soil Capability
Coarse-textured glacial till	Shawnigan	gravelly sandy loam	18 to 20 inches of pale brown and light yellowish brown permeable granular gravelly sandy loam overlying a grey, compact very permeable gravelly sandy loam.	Good	Moderate except in parent material where it is very low	1.7	Unsuited to agriculture because of rolling topography, stoniness, low fertility, and high clearing costs. Well suited to forest growth
Shallow medium textured glacial till underlain by shale and sandstone	Haslam	Shaly loam	Dark brown granular shaly loam over a 6 to 10 inch yellowish brown subangular blocky and very permeable shaly loam underlain by fractured and moderately permeable shale and sandstone.	Good	Moderate even in parent material	-	Unsuited to agriculture because of droughtiness, low fertility, and rock outcrops. Best suited to forest growth.
Coarse-textured marine material underlain by glacial till or marine clay.	Dashwood	Gravelly loamy sand	25 to 30 inches of yellowish brown loose permeable gravelly loamy sand overlying grey, very slowly permeable sandy till or marine clay.	Excessive to moderate	High to moderate in solum, very slow in D horizon resulting in lateral movement along D Horizon.	-	Non-agricultural because of stoniness, coarse texture, low moisture holding capacity, low fertility, high clearing costs Good for forest growth because of perched water table above D horizon.

Appendix I (Cont'd)

Parent Material	Soil Type	Texture	Profile	Drainage	Permeability	Soil Moisture Storage Capacity for Eight inches of soil	Soil Capability
	Lazo	primarily loamy sand	8 to 12 inches of dark very permeable sand, sandy loam or loam. 9 to 11 inches of yellowish brown highly permeable sandy loam, or loam, often gravelly or stony, and a parent material of grey, very slowly permeable gravelly sandy loam till	Good	Rapid to moderate in A and B horizons, very slow in D horizon resulting in lateral movement along D horizon.	-	Inferior farm land because of low fertility and low moisture holding capacity. Irrigation necessary. Good for forest growth.
	Bowser	Loamy Sand	20 to 30 inches of reddish brown loamy sand, over 4 to 6 inches of yellowish brown to reddish brown strongly cemented orstein , over very slowly permeable gravelly sandy loam till or marine clay.	Imperfect	High to moderate in solum. Very slow in D horizon resulting in lateral movement along D horizon.	0.7	Inferior for agriculture because moisture holding capacity of solum is low. Good for forests as subsoil is moist.
	Parksville	Sandy loam	5 to 6 inches of dark greyish brown, very permeable granular sandy loam overlying 4 to 5 inches of brown permeable loamy sand over 14 to 16 inches of yellowish brown compact and slowly permeable gravelly sandy loam till or marine clay	Poor	Moderate in solum, low in D horizon	-	Inferior for agriculture because of occurrence in small pockets, wetness, and slowness to warm up.

Appendix I (Cont'd)

Parent Material	Soil Type	Texture	Profile	Drainage	Permeability	Soil Moisture Storage Capacity for Eight inches of soil	Soil Capability
Medium to fine-textured marine materials underlain by marine clay or glacial till	Merville	Loam	6 to 10 inches of dark brown granular permeable sandy loam or loam over brown granular to subangular blocky very permeable loam, underlain by grey very slowly permeable plastic marine clay.	Moderately good	Moderate in A and B horizon, slow in D so soil is saturated to within one foot of the surface in winter	1.1	Suited to general farming
	Puntledge	Silt loam	15 to 18 inches of yellowish red to yellowish brown granular to subangular blocky and very permeable silt loam overlying grey, plastic and slowly permeable marine clay	Moderate to imperfect	High in B horizon, very slow in D horizon so that soil is saturated to within one foot of the surface in winter	1.0	Suited to agriculture but requires irrigation in July and August
	Tolmie	Sandy clay loam	6 to 9 inches very dark brown to black granular fine sandy loam to sandy clay loam over 4 inches of grey to greyish brown slowly permeable subangular blocky sandy clay loam, over 8 inches of slowly permeable sandy clay, over grey compact, very slowly permeable marine clay or glacial till.	Poor	Very slow below A horizon	1.0	Suited to agriculture with fertilizers and irrigation. Drainage is often necessary

Appendix I (Cont'd)

Parent Material	Soil Type	Texture	Profile	Drainage	Permeability	Soil Moisture Storage Capacity for Eight inches of soil	Soil Capability
Fine textured marine material	Fairbridge	Silt loam to silty clay loam	10 to 12 inches of brown to light yellowish brown highly concretionary and very permeable silty clay loam overlying 7 to 10 inches of pale brown blocky permeable silty clay loam, over coarse blocky, very slowly permeable marine silty clay.	Good	Slow in C horizon, moderate in D	1.4	Well suited to agriculture particularly under irrigation
	Cowichan	Clay loam	6 to 8 inches of dark greyish brown to black granular clay loam over 4 to 6 inches of very pale brown slowly permeable subangular blocky clay loam, underlain by pale brown, highly plastic and very slowly permeable marine clay.	Poor	Intermediate for A horizon, very low for others	1.6	Suited to agriculture under irrigation. Slow to warm up in spring. Good for forests.
Coarse textured, glacial-fluvial, aeolian and marine materials	Qualicum	Gravelly loamy sand or loamy sand	36 to 44 inches of yellowish to brown to pale brown loose, very permeable loamy sand or gravelly loamy sand overlying pale brown or grey loose sand or gravel	Rapid	High	0.8	Submarginal for agriculture because of low fertility and low moisture holding capacity

Appendix I (Cont'd)

Parent Material	Soil Type	Texture	Profile	Drainage	Permeability	Soil Moisture Storage Capacity for Eight inches of soil	Soil Capability
Medium-textured alluvium with undifferentiated drainage	Chemainus	Fine sandy loam to clay loam	3 to 6 inches of dark brown granular permeable fine sandy loam to clay loam over greyish brown permeable stratified alluvium	Variable	Moderate	1.4	Well suited to agriculture where drainage is good
Coarse textured alluvium with indifferentiated drainage	Cassidy	Sandy loam to stony sand	2 to 4 inches of dark brown granular gravelly loamy sand, loamy sand, or sandy loam over brownish grey, very permeable gravelly alluvium	Rapid	High	-	Unsuited to agriculture. Good for forests or protecting stream channels by regulating run-off
Organic Materials	Arrowsmith	Peat	Mosses and woody accumulations several feet deep	Poor	Moderate	-	Unsuited to agriculture because of difficulty of clearing and need for drainage.

Source: J.H. Day et al., Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia, by J.H. Day, L. Forstad, and D.G. Laird, British Columbia Soil Survey, Report No. 6, Victoria, 1959, 104 pp.

APPENDIX II

WATER BALANCE TABLES FOR COWICHAN BAY, DUNCAN, AND COWICHAN LAKE FORESTRY FOR SIX SOIL MOISTURE STORAGE CAPACITIES

Cowichan Bay - Water Balance Summary - 1" Storage

Year	Precipitation	P.E.[1]	Deficit	Surplus	Storage Change	E.T.[2]
1938	28.8	23.7	12.5	17.6	0	11.2
1939	40.9	24.4	12.0	28.5	0	12.4
1940	38.7	24.7	10.9	24.9	0	13.8
1941	37.3	24.4	8.7	21.6	0	15.7
1942	25.9	23.8	12.1	14.2	0	11.7
1943	22.7	23.2	11.1	10.6	0	12.1
1944	17.9	23.4	13.9	8.4	0	9.5
1945	33.9	22.9	10.9	21.9	0	12.0
1946	33.3	23.6	11.3	21.0	0	12.3
1947	33.3	23.7	12.0	21.0	0	11.7
1948	48.5	22.7	5.6	31.4	0	17.1
1949	37.8	23.3	11.5	26.0	0	11.8
1950	43.9	23.3	11.8	32.4	0	11.5
1951	-	-	-	-	-	-
1952	27.7	24.5	14.4	17.6	0	10.1
1953	46.7	24.8	9.0	29.2	0	15.8
1954	48.6	22.9	9.2	34.9	0	13.7
1955	39.8	21.9	9.1	27.0	0	12.8
1956	39.3	23.1	10.0	26.2	0	13.1
1957	34.1	23.2	9.3	20.2	0	13.9
1958	41.3	25.1	12.9	29.1	0	12.2
1959	36.5	23.4	7.8	20.9	0	15.6
1960	39.4	23.0	10.0	26.4	0	13.0
1961	47.0	24.8	12.0	34.2	0	12.8
1962	39.9	22.7	6.9	24.1	0	15.8
1963	40.9	24.7	9.7	25.9	0	15.0
1964	35.2	23.3	9.7	21.6	0	13.6
Total	959.3	614.5	274.3	616.8	0	340.2
Average	36.9	23.6	10.6	23.7	0	13.1

[1] Potential evapotranspiration

[2] Actual evapotranspiration

Source: Department of Transport, Meteorological Branch, Monthly Records 1938-1964 and computed according to Thornthwaite (1948)

Cowichan Bay - Water Balance Summary - 2" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	28.8	23.7	11.5	16.6	0	12.2
1939	40.9	24.4	11.0	27.5	0	13.4
1940	38.7	24.7	9.9	23.9	0	14.8
1941	37.3	24.4	7.7	20.6	0	16.7
1942	25.9	23.8	11.1	13.2	0	12.7
1943	22.7	23.2	10.1	9.6	0	13.1
1944	17.9	23.4	12.9	7.4	0	10.5
1945	33.9	22.9	9.9	20.9	0	13.0
1946	33.3	23.6	10.3	20.0	0	13.3
1947	33.3	23.7	11.0	20.6	0	12.7
1948	48.5	22.7	4.6	30.4	0	18.1
1949	37.8	23.3	10.5	25.0	0	12.8
1950	43.9	23.3	10.8	31.4	0	12.5
1951	-	-	-	-	-	-
1952	27.7	24.5	13.4	16.6	0	11.1
1953	46.7	24.8	8.0	28.2	0	16.8
1954	48.6	22.9	8.2	33.9	0	14.7
1955	39.8	21.9	8.1	26.0	0	13.8
1956	39.3	23.1	9.0	25.2	0	14.1
1957	34.1	23.2	8.3	19.2	0	14.9
1958	41.3	25.1	11.9	28.1	0	13.2
1959	36.5	23.4	6.8	19.9	0	16.6
1960	39.4	23.0	9.0	25.4	0	14.0
1961	47.0	24.8	11.0	33.2	0	13.8
1962	39.9	22.7	5.9	23.1	0	16.8
1963	40.9	24.7	8.7	24.9	0	16.0
1964	35.2	23.3	8.7	20.6	0	14.6
Total	959.3	614.5	248.3	590.8	0	366.2
Average	36.9	23.6	9.6	22.7	0	14.1

Cowichan Bay - Water Balance Summary - 4" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	28.8	23.7	9.5	14.6	0	14.2
1939	40.9	24.4	9.0	25.5	0	15.4
1940	38.7	24.7	7.9	21.9	0	16.8
1941	37.3	24.4	8.7	18.6	0	18.7
1942	25.9	23.8	9.1	11.2	0	14.7
1943	22.7	23.2	8.1	7.6	0	15.1
1944	17.9	23.4	10.9	5.4	0	12.5
1945	33.9	22.9	7.9	18.9	0	15.0
1946	33.3	23.6	8.3	18.0	0	15.3
1947	33.3	23.7	9.0	18.6	0	14.7
1948	48.5	22.7	2.6	28.4	0	20.1
1949	37.8	23.3	8.5	23.0	0	14.8
1950	43.9	23.3	8.8	29.4	0	14.5
1951	-	-	-	-	-	-
1952	27.7	24.5	11.4	14.6	0	13.1
1953	46.7	24.8	6.0	26.2	0	18.8
1954	48.6	22.9	6.2	31.9	0	16.7
1955	39.8	21.9	6.1	24.0	0	15.8
1956	39.3	23.1	7.0	23.2	0	16.1
1957	34.1	23.2	6.3	17.2	0	16.9
1958	41.3	25.1	9.9	26.1	0	15.2
1959	36.5	23.4	4.8	17.9	0	18.6
1960	39.4	23.0	7.0	23.4	0	16.0
1961	47.0	24.8	9.0	31.2	0	15.8
1962	39.9	22.7	3.9	21.1	0	18.8
1963	40.9	24.7	6.7	22.9	0	18.0
1964	35.2	23.3	6.7	18.6	0	16.6
Total	959.3	614.5	196.3	539.4	0	418.2
Average	36.9	23.6	7.6	18.7	0	16.1

Cowichan Bay - Water Balance Summary - 8" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	28.8	23.7	5.5	10.6	0	18.2
1939	40.9	24.4	5.0	21.5	0	21.4
1940	38.7	24.7	3.9	17.9	0	20.8
1941	37.3	24.4	1.7	14.6	0	22.7
1942	25.9	23.8	5.1	7.2	0	20.7
1943	22.7	23.2	4.1	7.1	-3.5	19.1
1944	17.9	23.4	7.4	0	+1.9	16.0
1945	33.9	22.9	3.9	13.3	+1.6	19.0
1946	33.3	23.6	4.3	14.0	0	19.3
1947	33.3	23.7	5.0	14.6	0	15.7
1948	48.5	22.7	0	27.8	0	22.7
1949	37.8	23.3	4.5	19.0	0	18.8
1950	43.9	23.3	4.8	25.4	0	18.5
1951	-	-	-	-	-	-
1952	27.7	24.5	7.4	10.6	0	17.1
1953	46.7	24.8	2.0	22.0	0	22.8
1954	48.6	22.9	2.2	27.9	0	20.7
1955	39.8	21.9	2.1	20.0	0	19.8
1956	39.3	23.1	3.0	19.2	0	20.1
1957	34.1	23.2	2.3	13.2	0	20.9
1958	41.3	25.1	5.9	22.1	0	19.2
1959	36.5	23.4	0.8	13.9	0	22.6
1960	39.4	23.0	3.0	19.4	0	20.0
1961	47.0	24.8	5.0	27.2	0	19.8
1962	39.9	22.7	0	17.2	0	22.7
1963	40.9	24.7	2.7	18.9	0	22.0
1964	35.2	23.3	2.7	14.6	0	20.6
Total	959.3	614.5	94.3	439.2	0	522.2
Average	36.9	23.6	3.6	16.9	0	20.1

Cowichan Bay - Water Balance Summary - 10" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	28.8	23.7	3.5	8.6	0	20.2
1939	40.9	24.4	3.0	19.5	0	21.4
1940	38.7	24.7	1.9	15.9	0	22.8
1941	37.3	24.4	0	12.9	0	24.4
1942	25.9	23.8	3.1	5.2	0	20.7
1943	22.7	23.2	2.1	7.1	-5.5	21.1
1944	17.9	23.4	3.4	0	+1.9	20.4
1945	33.9	22.9	1.9	9.3	+3.6	21.0
1946	33.3	23.6	2.3	13.3	-1.3	21.3
1947	33.3	23.7	3.0	11.3	+1.3	20.7
1948	48.5	22.7	0	24.8	0	22.7
1949	37.8	23.3	2.5	17.0	0	20.8
1950	43.9	23.3	2.8	23.4	0	21.5
1951	-	-	-	-	-	-
1952	27.7	24.5	5.4	10.3	-1.7	19.1
1953	46.7	24.8	0	20.2	+1.7	24.8
1954	48.6	22.9	0.2	25.9	0	22.7
1955	39.8	21.9	0.1	18.0	0	21.8
1956	39.3	23.1	1.0	17.2	0	22.1
1957	34.1	23.2	0.3	12.4	-1.2	22.9
1958	41.3	25.1	3.9	18.9	+1.2	21.2
1959	36.5	23.4	0	13.1	0	23.4
1960	39.4	23.0	1.0	17.4	0	22.0
1961	47.0	24.8	3.0	25.2	0	21.8
1962	39.9	22.7	0	17.2	0	22.7
1963	40.9	24.7	0.7	16.9	0	24.0
1964	35.2	23.3	0.7	12.6	0	22.6
Total	959.3	614.5	45.8	393.6	0	570.1
Average	36.9	23.6	1.8	15.1	0	21.9

Cowichan Bay - Water Balance Summary - 12" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	28.8	23.7	1.5	6.6	0	22.2
1939	40.9	24.4	1.0	17.5	0	23.4
1940	38.7	24.7	0	14.0	0	24.7
1941	37.3	24.4	0	12.9	0	24.4
1942	25.9	23.8	1.1	3.5	-0.3	22.7
1943	22.7	23.2	0.1	6.8	-7.2	23.1
1944	17.9	23.4	3.4	0	+1.9	20.0
1945	33.9	22.9	0	5.4	+5.6	22.9
1946	33.3	23.6	0.3	13.3	-3.3	23.3
1947	33.3	23.7	1.0	8.3	+2.3	22.7
1948	48.5	22.7	0	24.8	+1.0	22.7
1949	37.8	23.3	0.5	15.0	0	22.8
1950	43.9	23.3	0.8	21.4	0	23.5
1951	-	-	-	-	-	-
1952	27.7	24.5	3.4	10.3	-3.7	21.1
1953	46.7	24.8	0	18.2	+3.7	24.8
1954	48.6	22.9	0	25.7	0	22.9
1955	39.8	21.9	0	17.9	0	21.9
1956	39.3	23.1	0	16.2	0	23.1
1957	34.1	23.2	0	12.4	-1.5	23.2
1958	41.3	25.1	1.9	16.6	+1.5	23.2
1959	36.5	23.4	0	13.1	0	23.4
1960	39.4	23.0	0	16.6	-0.2	23.0
1961	47.0	24.8	1.0	23.0	+0.2	23.8
1962	39.9	22.7	0	17.2	0	22.7
1963	40.9	24.7	0	16.2	0	24.7
1964	35.2	23.3	0	12.0	-0.1	23.3
Total	959.3	614.5	16.0	364.9	0	599.5
Average	36.9	23.6	0.6	14.0	0	23.1

Duncan - Water Balance Summary - 1" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	32.2	25.1	13.9	21.0	0	11.2
1939	45.2	24.6	11.5	32.1	0	13.1
1940	43.1	24.7	9.5	27.9	0	15.2
1941	45.1	24.4	6.7	27.4	0	17.7
1942	31.4	24.5	11.8	18.7	0	12.7
1943	34.0	24.2	10.9	20.7	0	13.3
1944	28.5	24.2	13.7	18.0	0	10.5
1945	42.5	24.6	11.6	29.5	0	13.0
1946	37.4	24.0	11.0	24.4	0	13.0
1947	43.7	24.5	11.3	30.5	0	13.2
1948	50.2	23.4	8.2	34.0	0	15.2
1949	36.7	23.1	10.8	24.4	0	12.3
1950	48.8	22.4	10.6	37.0	0	11.8
1951	46.5	23.0	13.5	37.0	0	9.5
1952	32.3	22.8	12.9	22.4	0	9.9
1953	48.9	26.2	10.9	33.7	0	15.3
1954	52.3	23.4	9.0	37.9	0	14.4
1955	41.4	23.7	10.1	27.8	0	13.6
1956	42.8	24.5	10.7	29.0	0	13.8
Total	783.0	457.3	208.6	533.4	0	248.7
Average	41.2	24.1	11.0	28.1	0	13.1

Duncan - Water Balance Summary - 2" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	32.2	25.1	12.9	20.0	0	12.2
1939	45.2	24.6	10.5	31.1	0	14.1
1940	43.1	24.7	8.5	26.9	0	16.2
1941	45.1	24.4	5.7	26.4	0	18.7
1942	31.4	24.5	10.8	17.7	0	13.7
1943	34.0	24.2	9.9	19.7	0	14.3
1944	28.5	24.2	12.7	17.0	0	11.5
1945	42.5	24.6	10.6	28.5	0	14.0
1946	37.4	24.0	10.0	23.4	0	14.0
1947	43.7	24.5	10.3	29.5	0	14.2
1948	50.2	23.4	6.2	33.0	0	16.2
1949	36.7	23.1	9.8	23.4	0	13.3
1950	48.8	22.4	9.6	36.0	0	12.8
1951	46.5	23.0	12.5	36.0	0	10.5
1952	32.3	22.8	11.9	21.4	0	10.9
1953	48.9	26.2	9.9	32.7	0	16.3
1954	52.3	23.4	8.0	36.9	0	15.4
1955	41.4	23.7	9.1	26.8	0	14.6
1956	42.8	24.5	9.7	28.0	0	14.8
Total	783.0	457.3	188.6	514.4	0	267.7
Average	41.2	24.1	9.9	27.1	0	14.1

Duncan - Water Balance Summary - 4" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	32.2	25.1	10.9	18.0	0	14.2
1939	45.2	24.6	8.5	29.1	0	16.1
1940	43.1	24.7	6.5	24.9	0	18.2
1941	45.1	24.4	3.7	24.4	0	20.7
1942	31.4	24.5	8.8	15.7	0	15.7
1943	34.0	24.2	7.9	17.7	0	16.3
1944	28.5	24.2	10.7	15.0	0	13.5
1945	42.5	24.6	8.6	26.5	0	16.0
1946	37.4	24.0	8.0	21.4	0	16.0
1947	43.7	24.5	8.3	27.5	0	16.2
1948	50.2	23.4	4.2	31.0	0	18.2
1949	36.7	23.1	7.8	21.4	0	15.3
1950	48.8	22.4	7.6	34.0	0	14.8
1951	46.5	23.0	10.5	34.0	0	12.5
1952	32.3	22.8	9.9	19.4	0	12.9
1953	48.9	26.2	7.9	30.7	0	18.3
1954	52.3	23.4	6.0	34.9	0	17.4
1955	41.4	23.7	7.1	24.8	0	16.6
1956	42.8	24.5	7.7	26.0	0	16.8
Total	783.0	457.3	150.6	476.4	0	305.7
Average	41.2	24.1	7.9	25.1	0	16.1

Duncan - Water Balance Summary - 8" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	32.2	25.1	6.9	14.0	0	18.2
1939	45.2	24.6	4.5	25.1	0	20.1
1940	43.1	24.7	2.5	20.9	0	22.2
1941	45.1	24.4	0	20.7	0	24.4
1942	31.4	24.5	4.8	11.7	0	19.7
1943	34.0	24.2	3.9	14.2	-0.5	20.3
1944	28.5	24.2	6.7	10.5	+0.5	17.5
1945	42.5	24.6	4.6	22.5	0	20.0
1946	37.4	24.0	4.0	17.4	0	20.0
1947	43.7	24.5	4.3	23.5	0	20.2
1948	50.2	23.4	0.2	27.0	0	22.2
1949	36.7	23.1	3.8	17.4	0	19.3
1950	48.8	22.4	3.6	30.0	0	18.8
1951	46.5	23.0	6.5	30.0	0	16.5
1952	32.3	22.8	5.9	15.4	0	16.9
1953	48.9	26.2	3.9	26.7	0	22.3
1954	52.3	23.4	2.0	30.9	0	21.4
1955	41.4	23.7	3.1	20.8	0	20.6
1956	42.8	24.5	3.7	22.0	0	20.8
Total	783.0	457.3	74.9	400.7	0	399.4
Average	41.2	24.1	3.9	21.1	0	21.0

Duncan - Water Balance Summary - 10" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	32.2	25.1	4.9	12.0	0	20.2
1939	45.2	24.6	2.5	23.1	0	21.1
1940	43.1	24.7	0.5	18.9	0	24.2
1941	45.1	24.4	0	20.7	0	24.4
1942	31.4	24.5	2.8	9.7	0	21.7
1943	34.0	24.2	1.9	14.2	-2.5	21.3
1944	28.5	24.2	4.7	7.5	+1.5	19.5
1945	42.5	24.6	2.6	19.5	+1.0	22.0
1946	37.4	24.0	2.0	15.4	0	22.0
1947	43.7	24.5	2.3	21.5	0	22.0
1948	50.2	23.4	0	26.8	0	23.4
1949	36.7	23.1	1.8	15.4	0	21.3
1950	48.8	22.4	1.6	28.0	0	20.8
1951	46.5	23.0	4.5	28.0	0	18.5
1952	32.3	22.8	3.9	13.4	0	18.9
1953	48.9	26.2	1.9	24.7	0	24.3
1954	52.3	23.4	0	28.4	0	23.4
1955	41.4	23.7	1.1	18.8	0	22.6
1956	42.8	24.5	1.7	20.0	0	22.8
Total	783.0	457.3	40.7	366.0	0	414.4
Average	41.2	24.1	2.1	19.3	0	21.8

Duncan - Water Balance Summary - 12" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1938	32.2	25.1	2.9	10.0	0	23.2
1939	45.2	24.6	0.5	21.1	0	23.1
1940	43.1	24.7	0	18.4	0	24.7
1941	45.1	24.4	0	20.7	0	24.4
1942	31.4	24.5	0.8	7.7	0	23.7
1943	34.0	24.2	0	14.2	-4.4	24.2
1944	28.5	24.2	2.7	5.6	+1.4	21.5
1945	42.5	24.6	0.6	15.5	+3.0	24.0
1946	37.4	24.0	0	14.3	-0.9	24.0
1947	43.7	24.5	0.3	18.6	+0.9	24.2
1948	50.2	23.4	0	26.8	0	23.4
1949	36.7	23.1	0	13.6	0	23.1
1950	48.8	22.4	0	26.4	0	22.4
1951	46.5	23.0	2.5	26.0	0	20.5
1952	32.3	22.8	1.9	13.3	-1.9	20.9
1953	48.9	26.2	0	20.8	+1.9	26.2
1954	52.3	23.4	0	28.9	0	23.4
1955	41.4	23.7	0	17.7	0	23.7
1956	42.8	24.5	0	18.3	0	24.5
Total	783.0	457.3	12.2	337.9	0	445.1
Average	41.2	24.1	0.6	17.8	0	23.4

Cowichan Lake Forestry - Water Balance Summary - 1" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1950	92.2	28.7	10.3	73.8	0	18.4
1951	72.7	24.4	12.4	60.7	0	12.0
1952	70.8	24.4	9.7	56.1	0	14.7
1953	98.7	24.6	6.2	80.3	0	18.4
1954	106.5	23.2	4.6	87.9	0	18.6
1955	83.2	23.7	7.6	67.1	0	16.1
1956	81.9	23.9	10.1	68.1	0	13.8
1957	--	--	--	--	-	--
1958	--	--	--	--	-	--
1959	--	--	--	--	-	--
1960	--	--	--	--	-	--
1961	100.9	27.3	10.0	83.6	0	17.3
1962	87.0	24.9	4.8	66.9	0	20.1
1963	98.0	25.9	6.1	78.5	0	19.8
1964	--	--	--	--	-	--
Total	891.6	251.0	81.8	723.0	0	169.2
Average	89.2	25.1	8.2	72.3	0	16.9

Cowichan Lake Forestry - Water Balance Summary - 2" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1950	92.2	28.7	9.3	72.8	0	19.4
1951	72.7	24.4	11.4	59.7	0	13.0
1952	70.8	24.4	8.7	55.1	0	15.7
1953	98.7	24.6	5.2	79.3	0	19.4
1954	106.5	23.2	3.6	86.9	0	19.6
1955	83.2	23.7	6.6	66.1	0	17.1
1956	81.9	23.9	8.1	66.1	0	15.8
1957	--	--	--	--	-	--
1958	--	--	--	--	-	--
1959	--	--	--	--	-	--
1960	--	--	--	--	-	--
1961	100.9	27.3	9.0	83.6	0	18.3
1962	87.0	24.9	3.8	65.9	0	21.1
1963	98.0	25.9	5.1	77.5	0	20.8
1964	--	--	--	--	-	--
Total	891.6	251.0	69.8	713.0	0	180.2
Average	89.2	25.1	7.0	71.3	0	18.0

Cowichan Lake Forestry - Water Balance Summary - 4" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1950	92.2	28.7	7.3	70.8	0	21.4
1951	72.7	24.4	9.4	57.7	0	15.0
1952	70.8	24.4	6.7	53.1	0	17.7
1953	98.7	24.6	3.2	77.3	0	21.4
1954	106.5	23.2	1.6	84.9	0	21.6
1955	83.2	23.7	4.6	64.1	0	19.1
1956	81.9	23.9	4.6	62.6	0	19.3
1957	--	--	-	--	-	--
1958	--	--	-	--	-	--
1959	--	--	-	--	-	--
1960	--	--	-	--	-	--
1961	100.9	27.3	7.0	80.6	0	20.3
1962	87.0	24.9	1.8	63.9	0	23.1
1963	98.0	25.9	3.1	75.5	0	22.8
1964	--	--	-	--	-	--
Total	891.6	251.0	49.3	690.5	0	201.7
Average	89.2	25.1	4.9	69.0	0	20.2

Cowichan Lake Forestry - Water Balance Summary - 8" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1950	92.2	28.7	7.3	70.8	0	21.4
1951	72.7	24.4	5.4	53.7	0	19.0
1952	70.8	24.4	2.7	49.1	0	21.7
1953	98.7	24.6	0	74.1	0	24.6
1954	106.5	23.2	0	83.3	0	23.2
1955	83.2	23.7	0.6	60.1	0	23.1
1956	81.9	23.9	0.6	58.6	0	23.3
1957	--	--	-	--	-	--
1958	--	--	-	--	-	--
1959	--	--	-	--	-	--
1960	--	--	-	--	-	--
1961	100.9	27.3	3.0	76.6	0	24.3
1962	87.0	24.9	0	62.1	0	24.9
1963	98.0	25.9	0	72.4	0	25.9
1964	--	--	-	--	-	--
Total	891.6	251.0	19.6	660.8	0	231.4
Average	89.2	25.1	2.0	66.1	0	23.1

Cowichan Lake Forestry - Water Balance Summary - 10" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1950	92.2	28.7	1.3	64.8	0	27.4
1951	72.7	24.4	3.4	51.7	0	21.0
1952	70.8	24.4	0.7	47.1	0	23.7
1953	98.7	24.6	0	74.1	0	24.6
1954	106.5	23.2	0	83.3	0	23.2
1955	83.2	23.7	0	59.5	0	23.7
1956	81.9	23.9	0	58.0	0	23.9
1957	--	--	-	--	-	--
1958	--	--	-	--	-	--
1959	--	--	-	--	-	--
1960	--	--	-	--	-	--
1961	100.9	27.3	1.0	74.6	0	26.3
1962	87.0	24.9	0	62.1	0	24.9
1963	98.0	25.9	0	72.4	0	25.9
1964	--	--	-	--	-	--
Total	891.6	251.0	6.4	647.6	0	244.6
Average	89.2	25.1	0.6	65.0	0	24.5

Cowichan Lake Forestry - Water Balance Summary - 12" Storage

Year	Precipitation	P.E.	Deficit	Surplus	Storage Change	E.T.
1950	92.2	28.7	0	63.5	0	28.7
1951	72.7	24.4	1.4	49.7	0	23.0
1952	70.8	24.4	0	46.4	0	24.4
1953	98.7	24.6	0	74.1	0	24.6
1954	106.5	23.2	0	83.3	0	23.2
1955	83.2	23.7	0	59.5	0	23.7
1956	81.9	23.9	0	58.0	0	23.9
1957	--	--	-	--	-	--
1958	--	--	-	--	-	--
1959	--	--	-	--	-	--
1960	--	--	-	--	-	--
1961	100.9	27.3	0	73.6	0	27.3
1962	87.0	24.9	0	62.1	0	24.9
1963	98.0	25.9	0	72.4	0	25.9
1964	--	--	-	--	-	--
Total	891.6	251.0	1.4	642.6	0	249.6
Average	89.2	25.1	0.1	64.3	0	25.0

APPENDIX III

QUESTIONNAIRE

APPENDIX III

QUESTIONNAIRE

1. Name (Surname).....................Given name(s)..............

2. Land description: Section ....Range........Acreage.......
   Section ....Range........Acreage.......
   Section ....Range........Acreage.......

3. Source of domestic water: Stream.....Lake....Spring....Well...
   Other........

4. Volume of water used is ....

5. Number in household is ....

6. If you use a well what is its depth .... and type: hand dug
   ....drilled.......

7. Do you use a dugout? Yes.... No ....

8. Do you use water for a garden? Yes.... No ....
   If so, how often do you water your garden? Every day ......
   Every other day ....
   Weekly ....
   Other ....

9. Is your water supply adequate for the whole year? Yes...No....

10. Do you ever run out of water? Yes.... No ....
    How often ....
    During what season ....

11. Is the quality of your water supply good? Yes.... No.....
    If the answer is no, which of the following applies to your water supply?
    Pollution.......................
    Presence of sulphur ....
    Presence of iron...............
    Brackish taste.................
    Hardness.......................
    Other, please specify.....................................

12. Is the water on your land used for swimming ....or fishing
    ....?

13. Are parts of your land ever flooded? Yes.... No....
If so, please specify (eg., along river or in depressions)....
....

14. How often does flooding occur? Annually.... Once in 5 yrs....
Once in 10 yrs..............
Once in 20 yrs..............
Other.....................

15. During what period of the year does flooding occur? ....
....

16. Does flooding damage your land.......Machinery...............
Buildings...............
If so, to what extent..
....

17. Does the danger of flooding lower the resale value of your property? Yes.... No....

18. Do you farm on a full time basis? Yes.... No.....

19. If not, what is your main occupation? ....

20. Size of holding is .... acres.

21. Number of acres cultivated is ...., in woodland ...., in wasteland ....

22. Would you like to expand the cultivated area? Yes..... No.....

23. What factors prevent the expansion of cultivated land?
Cost of land ....
Cost of clearing...............
Need for drainage.............
Need for irrigation...........
Other, please specify...

24. Date of purchase of land ....

25. Date of original clearing of land ....

26. Principal agricultural enterprise.......................

27. Secondary agricultural enterprise.......................

28. Do you use fertilizers? Yes.... No....
    If so, which types do you use? Lime.... Manure....
    Chemical.... Other............

29. What is the value of land per acre in this area?.............

30. Source of stock water: Stream.... Lake.... Spring.... Well....
    Other.............

31. Volume of water used for stock is ....

32. Number and type of animals? Number .... Type ....

33. Do you irrigate? Crops: Yes.... No....
    Pasture: Yes.... No....

34. Source of irrigation water: Stream.... Lake.... Spring.......
    Well.... Other.................

35. Volume of water used for irrigation is ....

36. How often is water applied:
    Crops: once a season.... once in 4 wks. .... once in 3 wks....
    once in 2 wks.... Other ....
    Pasture: once a season.... once in 4 wks. .... once in 3 wks....
    once in 2 wks.... Other ....

37. How much water is used in one application? ....

38. Is irrigation a necessity in this area? Yes.... No ....

39. Would you expect an increase in yield with irrigation? Yes....
    No ....
    If yes, describe this increase (eg. the carrying capacity of the land for livestock would increase by so many head).........
    ....
    ....

40. What factors limit the use of irrigation?
    Lack of water ....
    Expense of installation.................
    Lack of increased income................
    Other, please specify ....
    ....

41. Have any lowlying areas on your land been drained for farming?
    Yes.... No .....

42. If so, are they more fertile than the rest of your land?
Yes.... No ....

43. Do these lowlying areas suffer from flooding? Yes.... No....

44. Does flooding on any part of your land affect your crops ....
Pasture ......

45. Is there any water erosion on your land? Yes.... No.....
If so, give time of year, part of farm (ie. upper slopes, bottom land) type (eg. gullies, loss of topsoil), and extent of erosion.
....
....
....

46. If there is water erosion have any steps been taken to combat it? Yes.... No ....
What were these steps? ....
....

Additional comments:

APPENDIX IV

PROVINCIAL PARK RESERVES COWICHAN RIVER BASIN

APPENDIX IV

PROVINCIAL PARK RESERVES COWICHAN RIVER BASIN

Location	Site Characteristics			Recreation Potential	Present Use
	Acreage	Frontage	Other		
Coastal Plain					
Cowichan Bay	1.15		Narrow strip of shoreline bordered inland by the road and a steeply rising terrace.	Boat-launching site, and parking facilities to service the sport salmon fishermen.	Cowichan Bay is used for the booming and shipping of logs. The site itself is used as a makeshift boat launching site.
West of Cowichan Station on Koksilah River	4.13		A riverside site with an old growth tree cover.	Fishing, swimming, wading, picnicking by local users	Limited because of poor access.
Koksilah River	30		River flat with old growth timber. Excellent pools for swimming at low water.	Heavy day use for swimming and picnicking anticipated	Limited
Cowichan River					
South Side of the river near Deerholme	65	3960'	Steep river banks flanking flat benches. Good access to the river via a logging road.	River access for fishing A parking lot and camping sites or picnic grounds could be developed on the river flat.	Fishing access
Upstream from the Deerholme reserve embracing both sides of the river.	244	1.75 mi.	Riverside flat and upper bench. River contains several large pools suited to fishing and swimming	Heavy use for fishing and swimming, picnicking and camping	Under heavy public use where access is available.

Appendix IV (Cont'd)

Location	Site Characteristics			Recreation Potential	Present Use
	Acreage	Frontage	Other		
Downstream from Marie Canyon	158		Downstream frontage is low and subject to flooding. Upstream frontage is an attractive riverside flat. No road access. Fisherman's trail is expected to provide access.	Fishing access and a "walk-in" campsite for hikers and fishermen using the Rod and Gun Club trail.	Fishing access
Upstream from Marie Canyon	7			Fishing access	Fishing access
Skutz Falls	154	8510'	Attractive riverside flat. Road access. Good fishing site.	Fishing access with small campsite and picnic facilities.	Heavy use for fishing access and picnicking. A key area in the fishing uses of the Cowichan River.
Rip's Road Picnic Site downstream from the Village of Lake Cowichan	154		Scenic riverside flat with fir and maple cover. Riffles and pools in the river suit it to fishing and swimming. Road access	Picnicking, fishing and swimming.	Picnic and camping site for local fishermen
Cowichan Lake					
North Shore, west of Village of Lake Cowichan	3.75		Lakeshore with beach. Road access.	Swimming and picnicking site to service the Village of Lake Cowichan and Youbou.	
North Shore, across from Honeymoon Bay	8		Attractive beach. Access by boat.	Limited use except by boating parties.	Limited

Appendix IV (Cont'd)

Location	Site Characteristics			Recreation Potential	Present Use
	Acreage	Frontage	Other		
Gordon Bay	67		Sloping rocky ground with scattered forest cover. Clean gravel beach, free from underwater snags, rapid dropoff. Road access.	Campground, picnicking, swimming and fishing. Heavy use anticipated.	Camping and picnicking. Facilities limited to two or three carloads.
North Shore, across from Caycuse	53		Attractive fine pebble beach suited to swimming. Swampy in places. Access by logging road or boat.	Swimming, picnicking and fishing	Limited access prevents use.
North Shore across from Caycuse	38		Gravel shoreline, gently sloping. Access by logging road or boat.	Swimming, picnicking and fishing. Boat camping a possibility.	Limited access prevents use.
South Shore, west of Caycuse	145		Pebble beach, sheltered bay. No road access. Boat access.	Swimming, picnicking and fishing.	Limited access prevents use.

Source: British Columbia Department of Recreation and Conservation, Parks Branch, Files.